

February 1959

Rec 2/6/59 mnt

space aeronautics

RESEARCH • DESIGN • DEVELOPMENT

aircraft / missiles / spacecraft

formerly Aviation Age

EXCLUSIVE...

...In this issue:

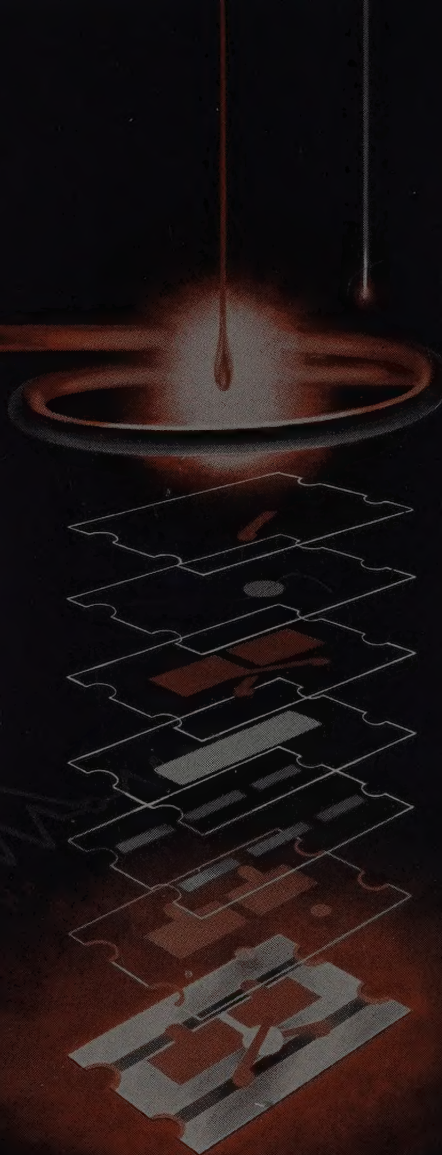
What is top Air Force
thinking on trends in
aircraft, missiles, and
spacecraft?

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Jupiter with operational GSE

A Conover-Mast Publication

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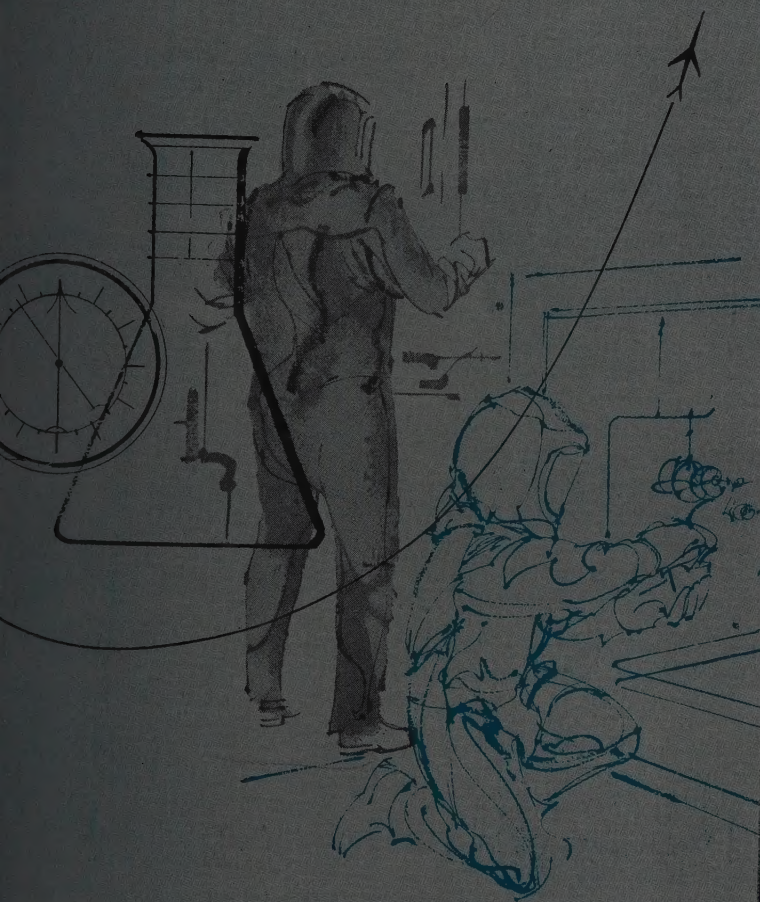
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Write in No. 1 on Reader Service Card
January 1959

Write in No. 273 on Reader-Service Card

high-energy fuel briefs from Callery

Successful start-up for new Muskogee, Oklahoma plant — Callery is successfully operating the first of four major processing units at the new \$38,000,000 Navy HiCal plant at Muskogee, Oklahoma. This plant will provide many times the production capacity of any existing high-energy fuel facility.

Lawrence, Kansas plant producing tonnage quantities of HiCal — All of the immediate capacity of the Lawrence plant is now under military contract. However, we do hope to have some HiCal available in the near future for *authorized users*. If you — or your program — qualify, we'd welcome an opportunity to discuss the technical aspects of using these fuels for your project.

Write for new HiCal-3 Handling Bulletin.

R & D on new fuels and propellants? — Callery's R & D experience may prove helpful in attaining your long range objectives. Our current exploration in a number of new phases of development may coincide with one or more of your pet projects. Project teams with up-to-date facilities at their disposal can now be assigned to new programs. We'd like to talk with you about those areas of mutual interest in which Callery is best qualified.

Pyrophoric ramjet fuel: Triethylborane — TEB is spontaneously flammable in air. However, it does not react with water, and this is a distinct handling and operational advantage. TEB — with much wider flammability limits than hydrocarbons — virtually eliminates engine flameouts at high altitudes. Some of the advantages of using TEB as a primary ramjet fuel in place of hydrocarbon-fueled ramjets are: higher altitude operation, increased range, improved fuel economy and reliability, and lower cost vehicles.

Write for Technical Bulletin C-310 and Handling Bulletin C-311.

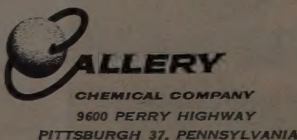
New 15-minute Triethylborane-Tributylborane fire-fighting film available for loan. Just write 9600 Perry Highway, Pittsburgh 37.

Washington, D. C. office opened by Callery — Fuel and propellant users in the Washington, D. C. area may now avail themselves of technical service at this new Callery office: Room 709, DuPont Circle Building, 1346 Connecticut Avenue, N.W. Phone Richard A. Carpenter, Manager, ADams 4-4200.

Note: Our recently opened office in Dayton, Ohio offers specialized technical assistance on fuels and propellants to interested parties in that area. Contact Anthony C. Hummel at 2600 Far Hills Avenue, phone AXminster 3-2752.



Richard A. Carpenter
Manager, Washington Office
Callery Chemical Company



Write in No. 274 on Reader Service Card at start of Product Review Section

space/aeronautics

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 ... GLENN L. MARTIN... SYSTEMS ♦ MAGNOLIA PETROLEUM

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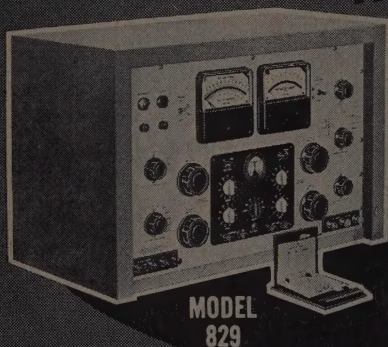
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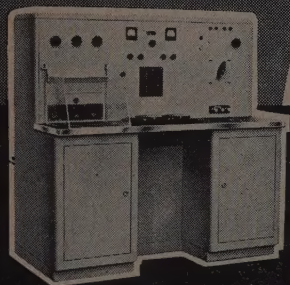
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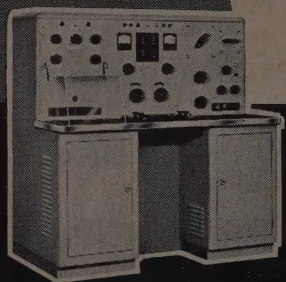
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Portable Model 829 calibrates both AC and DC meters over ranges from 0.25 millivolt to 2000 volts and 2 microamperes to 20 amperes. Direct reading accuracy of 1% (0.5% using charts supplied). Output frequency from 50 to 400 cps depending on line frequency used.

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**Radio Frequency
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cover story



Outstanding feature of the operational Jupiter IRBM is its panelized standby shelter, designed by Barnes & Reinecke, of Chicago. A prefab structure, the shelter protects the missile tail and personnel working on it.

The shelter has 12 base sections with hinged and rubber-edged two-part panels. These are raised electrically in three minutes to form a seal around the missile's hull.

A cable is strung around the midriff of the raised panels. Its tension and the support of 24 screw actuators holds the shelter in place even in hurricane winds. The cable is automatically released when the panels are lowered.

Because they are exposed to blast-off heat, four panels are made of plywood. This material will scorch only slightly, it's been found. The other panels are aluminum sheet over paper honeycomb.

The entire shelter can be assembled in eight hours by six men.

The short range Perkin-Elmer theodolite, used for the critical azimuth alignment of the Jupiter, is shown in the left foreground of the cover picture (see also "Theodolite Automatically Align Operational Jupiter," p. 106).

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SPACE/AERONAUTICS

meeting of minds

to find
the means...



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Write in No. 277 on Reader Service Card at start of Product Review Section

February 1959

volume 31, number 2

space aeronautics

RESEARCH • DESIGN • DEVELOPMENT

aircraft / missiles / spacecraft

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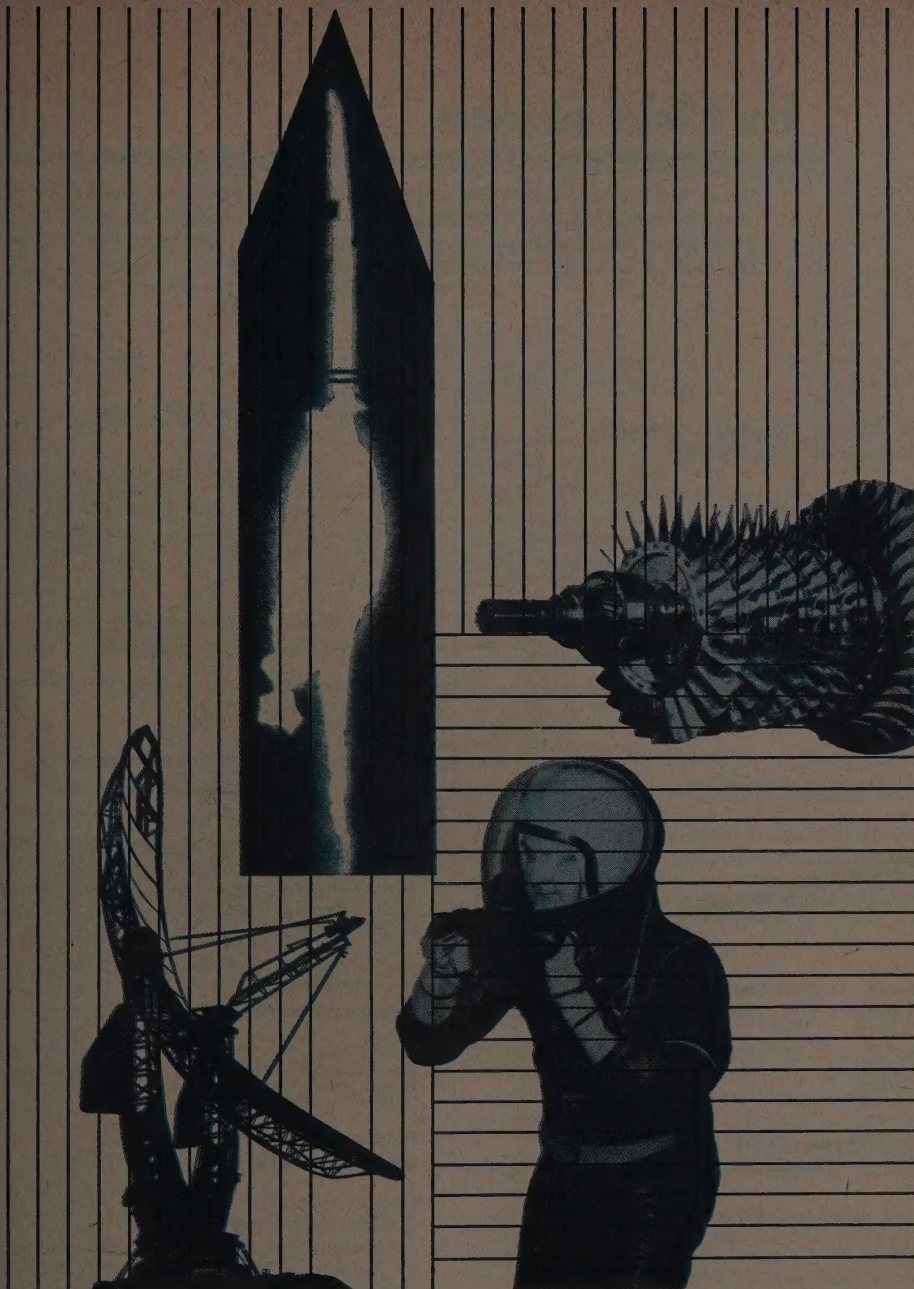
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The editorial content of Space/Aeronautics is regularly examined for readability by Robert Gunning Assoc., counselors in clear writing. These consultants meet periodically with the editors and discuss comparative readability ratings.



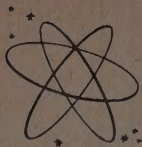
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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up a permanent record for future reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Space/Aero Engineering
Propulsion, Materials

Astia code: 21-2, -3, -4, -5,
-7, -8, -9; 27-2
Your code:

Airborne fission reactor controlled through neutron absorption

Condensed from Russian report published in 1957. Covers fundamentals of reactor control. Shows typical configurations and gives representative temperatures and reaction control times. Design details, including weights and sizes, of a uranium-beryllium reactor core.

by G. N. Nesterenko, A. I. Sobolev and Yu. N. Sushkov
space/aeronautics 31/2 (Feb. '59)

p. 43

Space/Aero Engineering
Materials, Structures

Astia code: 1-3; 17-1; 17-2; -4
Your code:

State of the art: Beryllium

Latest data on mechanical properties of beryllium collected by DMIC and Battelle Institute. Applications, experimental work, and trends are discussed. Based on interviews with Brush Beryllium and Battelle metallurgists.

by Irwin Stambler, Associate Editor
space/aeronautics 31/2 (Feb. '59)

p. 48

Space/Aero Engineering
System Engineering,
Propulsion, Accessory Systems

Astia code: 1-9; 27-2
Your code:

Fairey Rotodyne VTOL design and concept (Design Progress)

General and component design features of Fairey VTOL Rotodyne airliner. Pressure jet drive, noise suppression, rotor head, blade construction, and wing and fuselage structures are described. Two Napier Eland N-El-7 engines of 3500 ehp each provide main power.

by Randolph Hawthorne, Editor
space/aeronautics 31/2 (Feb. '59)

p. 55

Space/Aero Engineering
Propulsion

Astia code: 10-5
Your code:

Cyanogen and hydrogen cyanide studied for high energy rockets

Report on liquid propellant work at Temple U. Research Institute involving cyanogen and hydrogen cyanide fuels and LOX and fluorine oxidizers. Test results are given and indicated operating problems are discussed.

by Kurt R. Stehling, Contributing Technical Editor
space/aeronautics 31/2 (Feb. '59)

p. 62

Space/Aero Engineering
Systems Engineering

Astia code: 2-1; 7-1; 22-7; 27-3
Your code:

How feasible are Mars and Venus probes?

Design and operational problems of early, unmanned interplanetary probes. Propulsion, auxiliary power, and tracking system requirements are discussed in detail. Astrophysical experiments feasible with Mars and Venus probes are listed. Several possible configurations are illustrated.

by Englebert Kirchner, Managing Editor
space/aeronautics 31/2 (Feb. '59)

p. 46

Space/Aero Engineering
Ground Support

Astia code: 12-3
Your code:

"Gun barrel" launching saves ICBMs' first stages

Design proposal for launching of missiles and spacecraft under external power from vertical tunnels extending up to 20,000 ft into the earth. Weight or range savings of this method are explained and tunnel equipment is described in detail. Technique for drilling the tunnels is also covered.

by V. M. Tyler, E. C. Jackson and R. M. Pierce, Hughes Aircraft and Grand Central Rocket

space/aeronautics 31/2 (Feb. '59)

p. 52

Space/Aero Engineering
Systems Engineering, Aerodynamics,
Structures, Materials

Astia code: 1-2; 17-2; -4
Your code:

NAA's Vigilante uses new aluminum alloy

Design study of new A3J Navy twin-jet attack weapon system. Design features include the use of 2020 high temperature aluminum for skins and gold-plated titanium in engine area. Many maintenance features, such as jowl access doors and doors for work on installed and running engines are discussed.

by Irwin Stambler, Associate Editor
space/aeronautics 31/2 (Feb. '59)

p. 58

Space/Aero Engineering
Systems Engineering, Accessory Systems,
Electronics

Astia code: 12-1; -2; -3; -4
Your code:

British test missile designed for easy parts access

Design analysis of Short-Elliott GPV test missile for radar homing research. Details are given on configuration and propulsion, guidance, control, telemetry, and recovery systems.

by Randolph Hawthorne, Editor
space/aeronautics 31/2 (Feb. '59)

p. 66

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Forces Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Space/Aero Engineering
Accessory Components

Astia code: 12-2
Your code:

Spring-driven gyros have low drift rates

Present and future applications of spring-energized gyros for missiles and target drones. Shows pictures and electromechanical schematic of position gyro of current air-to-ground missile and gives its design and performance characteristics. In development are: 10-minute low drift gyro, subminiature two-axis control gyro, 1000-G gyro.

by K. W. Brown, Whittaker Gyro Div., Telecomputing Corp.

space/aeronautics 31/2 (Feb. '59)

p. 82

Space/Aero Engineering
Materials, Testing

Astia code: 14-2; 30-3
Your code:

New test methods give reliable cermet data

Test setups devised by Bureau of Standards to obtain mechanical properties of brittle cermets from tensile specimens. (Former tests gave conflicting results). Photographs of setups are shown as well as graphs of some results.

by Irwin Stambler, Associate Editor

space/aeronautics 31/2 (Feb. '59)

p. 86

Space/Aero Engineering
Accessory Systems

Astia code: 1-2
Your code:

Ram air turbines meet planes' emergency power needs

Use of ram air turbine to supply emergency power for hydraulic flight control. Requirements, design principles, and capabilities of systems using fixed and variable hydraulic pumps are discussed. System extension for emergency operation of aircraft utility system and emergency supply of electric power is also covered.

by J. M. Dutton and D. C. Connett, Vickers

space/aeronautics 31/2 (Feb. '59)

p. 96

Space/Aero Engineering
Ground Support

Astia code: 12-3
Your code:

Theodolites automatically align operational Jupiter

Azimuth alignment system of ballistic missiles with closeups of missile base structure and launching ring. Theodolites keep missile and its stable platform aligned within seconds of arc up to instant of launch, even with the missile swaying. Provision is made for primary and secondary target selection.

by Don Karshan

space/aeronautics 31/2 (Feb. '59)

p. 106

Space/Aero Engineering
Accessory Components, Testing

Astia code: 12-1, 2; 30-3
Your code:

Mach 1-10 sensor for re-entry angles and pressure

Design details of "Q-ball" sensor for angle of attack, sideslip angle, and dynamic pressure, developed for NASA by Nortronics. Servo mechanization is described and diagramed, and performance data are given. Unit is used for aircraft and missile re-entry measurements.

by Bernard Kovit, Assistant Electronics Editor

space/aeronautics 31/2 (Feb. '59)

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Space/Aero Electronics

Astia code: 19-3
Your code:

Adaptive control—new concept in automatic flight

Basic objectives and concepts of adaptive control system. System is described in building block fashion, with pitch stability augmentation loop used as example. Results of simulator and on F-94C flight trials are given.

by R. C. K. Lee, L. T. Prince & R. N. Bretoin, Minneapolis-Honeywell Regulator

space/aeronautics 31/2 (Feb. '59)

p. 128

Space/Aero Electronics

Astia code: 8-2
Your code:

Design tips on transistors in airborne equipment

Use of transistors in airborne electronic equipment, with emphasis on the limitations of the transistor. Based on lab and flight test analysis and customer polls by Collins Radio. A 40-W passenger address amplifier and a dc-dc power supply are cited as examples of airline-type transistorized equipment.

by Mel Caquelin, Collins Radio

space/aeronautics 31/2 (Feb. '59)

p. 132

Space/Aero Electronics

Astia code: 8-2; 12-3
Your code:

Solid state systems for fast automatic checkout

Completely automatic checkout systems can be built with solid state switching devices. Generalized system of this type is diagramed and described, and extensive flexibility provisions are analyzed.

by Max Palevsky and D. A. Domike, Packard-Bell Computer & Packard-Bell Electronics

space/aeronautics 31/2 (Feb. '59)

p. 135

continued on page 14



How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature -400° to 1000° F.
Pressure 500 psi
R.P.M. 80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a

temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in

a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

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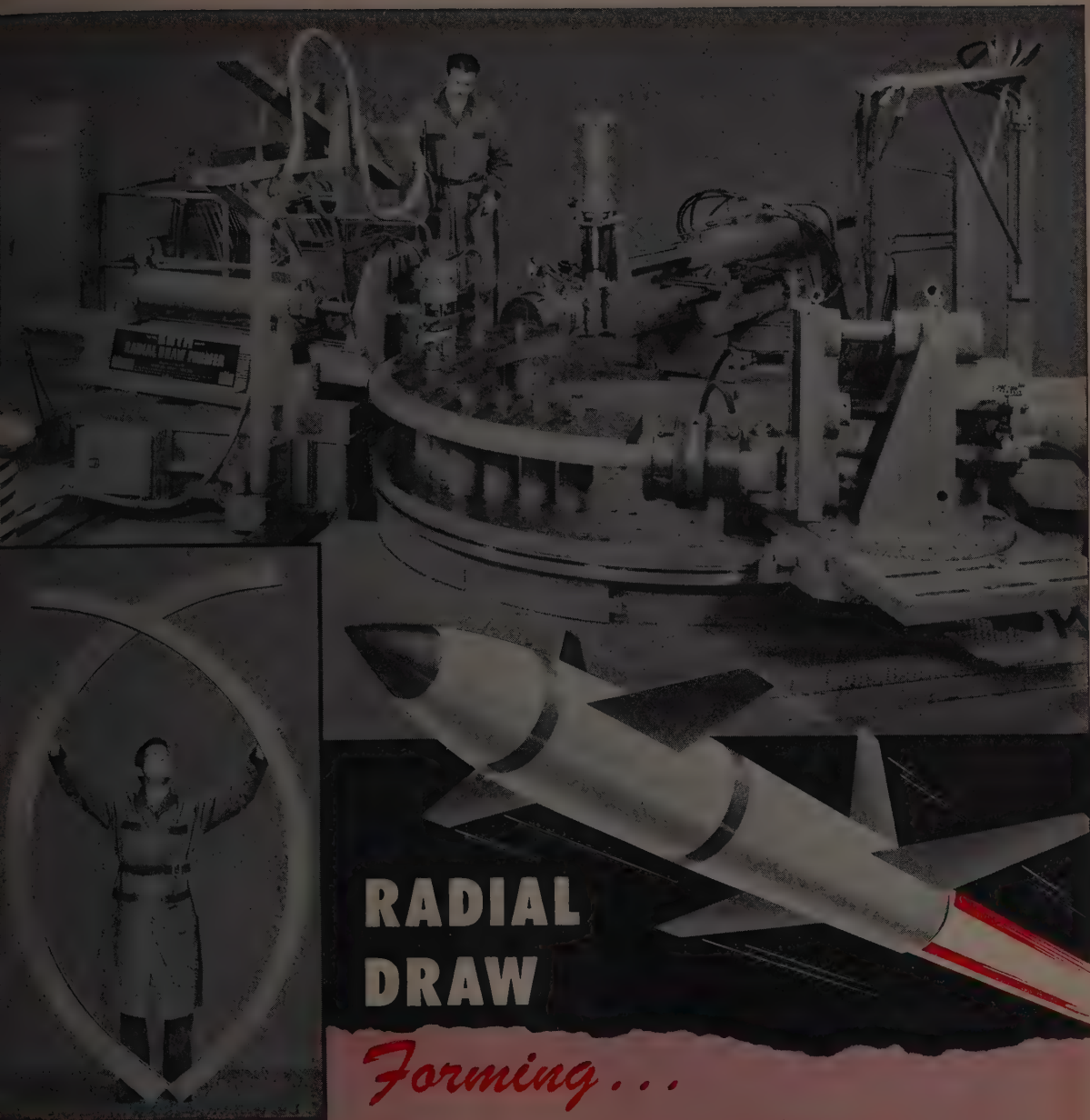
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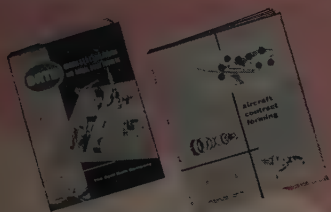
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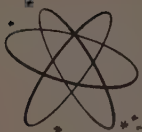
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in this issue continued from page 11

Space/Aero Electronics

Astia code: 19-3
Your code:

Ground-based monitor improves jet takeoff odds (Design Digest)

Wholly ground-based electronic jet takeoff monitor system proposed by Nortronics. Forces affecting jets during ground roll are summarized; analytical technique on which the computer design is based is derived. Diagrams illustrate both the overall system concept and major operational units.

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 31/2 (Feb. '59) p. 133

Space/Aero Electronics

Astia code: 8-2
Your code:

Conductive plastic pots upgrade transducers

Prime performance factors and advantages involved in using conductive plastic resistive elements in pressure transducers. Graphs plotting total and contact resistance changes vs number of wiper excursions are presented. New transducer designs and ranges are outlined.

by James P. Hunt, Rahm Instruments

space/aeronautics 31/2 (Feb. '59) p. 142

Space/Aero Electronics

Astia code: 8-1; 30-3
Your code:

Antenna testing: Mechanized rig develops gale winds

Thorough testing is needed to make sure large ground radar antennas will withstand the wind forces imposed on scan, tilt, and support mechanisms. Example of such testing is given in description of special hydromechanical test rig for GE FPS-33 long range search radar pedestal.

by James Holahan, Electronics Editor

space/aeronautics 31/2 (Feb. '59) p. 146

Space/Aero Electronics

Astia code: 8-2
Your code:

Astable multivibrator uses mesa transistors

Some characteristics of the mesa transistor are pointed out in a description of an astable multivibrator circuit using two Type 2N700 germanium models. Frequency and power potentials of the mesa types are given, and the low susceptibility of this device to nuclear radiation is explained.

by D. G. Paterson, Semiconductor Div., Motorola

space/aeronautics 31/2 (Feb. '59) p. 151

coming next month

IN ITS annual special report on space flight, SPACE/AERONAUTICS will give you a concise and comprehensive summary of our achievements and plans in astronautics. "State of the art" reports on vehicles, dynamics, electronics, accessory systems, and human factors will give you the overall picture; outstanding problem areas will be highlighted in articles by experts in the field (among their topics: system reliability prediction, ionization effects, plasma propulsion, and APU evaluation). A special reference section will present nomographs for the working engineer.

AMONG the new high performance antenna types, logarithmic periodic structures look especially promising. The lead article of the Space/Aero Electronics section will review their advantages and applications.


coming soon

SOLAR cells, it has become obvious, will play a major role in the auxiliary power supplies of our spacecraft. SPACE/AERONAUTICS is preparing a detailed review of the design and operating features of these important units.

Reader Service

Want to get more information on products or services advertised or mentioned editorially in this issue? Then use our handy Reader-Service Card opposite page 166. It's simple—just write in the number of the item you're interested in, drop the card into a mailbox, and we'll forward your inquiry.

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Stratoflex assemblies help fuel THE MIGHTY ATLAS

Every time a Convair Atlas intercontinental ballistic missile lifts from its Cape Canaveral launching pad, fantastic demands are made of the fueling system and powerplant.

A touch of the blast-off button triggers hundreds of simultaneous chain reactions in the giant ICBM's fuel system. Under tremendous pressure, liquid oxygen is delicately and precisely force-mixed with a kerosene-like fuel and flashes through the lines as vapor to feed the fires burning in the combustion chamber. This blend, mix, fire sequence must commence in a split second and continue at tremendous speed if the launch is to be successful. Fuel line plumbing on the Atlas must be absolutely leakproof, immune to strong vibrations, and able to withstand continuous temperature variations.

Despite the infinite possibilities for human mistake and material malfunction, the Air Force, aided by Convair technicians, has successfully launched the Atlas ICBM time after time at Cape Canaveral. (In the spectacular December 18, 1958 firing, the 85-foot Atlas was placed in orbit around the earth.) Stratoflex is proud that its specially-designed Teflon* hose and metal tubing assemblies are vital parts of the Atlas fuel line system.

* A DuPont trademark



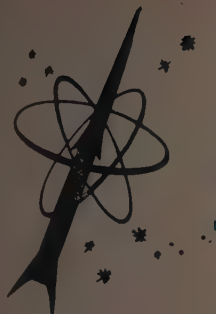
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Write in No. 282 on Reader Service Card at start of Product Review Section

SPACE/AERONAUTICS



editorial

Engineers for metric system

ENGINEERS and scientists favor the metric over the English system. They want a "cure for the inch-pound illness." So far, they back our December 1958 editorial calling for a change to metric measurement overwhelmingly (see *Letters*, page 250).

Most of the trouble in U.S. industry with weights and measures stems from the awkward conversion problem. Since the only legal materials standards are metric, the English system must be calibrated to the metric system. But, as Dr. A. V. Austin, National Bureau of Standards head, points out, there are now at least two "inches" used in the U.S.A., and three among the inch-using nations. The confusion and added cost this caused were spotlighted in World War II.

Presumably, part of the confusion will end when the new "international inch" goes into effect on July 1. But the conversion headache will stay to plague every engineering calculation made by those using the English units. Small errors thus introduced become more significant with the trend to greater precision. Final calculations, therefore, often are incorrect solely because of the lack of precision inherent in the system used.

THE TIME WASTED and accuracy lost—resulting in added cost—must be staggering. One reader says that often a half-day's activity is consumed in his field of thermal studies for airborne electronic equipment, a field "bewildering" to the English system.

The need for a common standard of weights and measures is accepted. This is shown by the English-system nations' agreement on a common inch-pound. But this only perpetuates the opposing metric and non-metric camps. Can the space/aeronautics field long endure two standards?

Moreover, the inch-pound will continue to be calibrated to the metric system in each of the English-system countries. So, the new standard will do nothing to relieve the conversion problems pointed out by our readers. It will do nothing to save the engineering hours consumed by these conversions. It will not eliminate the resulting errors creeping into computations.

WHAT IS THE REASON for clinging to a system that adds to the work burden and possibility of error in design and production? Is it "mental inertia", as one reader sees it?

Suggestions on how and when to make the changeover to metric measure are given by readers in their letters. These are good so far as they go. But we believe our readers who must "live" with a proposed changeover have other and more detailed programs in mind. Still others may be opposed to any change.

We invite your proposals and comments. . . **Randolph Hawthorne**

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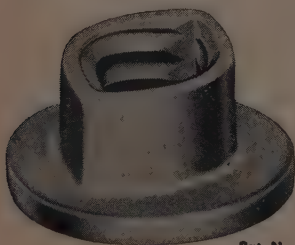
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Write in No. 283 on Reader Service Card at start of Product Review Section

by A. N. Weckler, Washington Bureau Chief

How much good are the Pentagon "czars"?

LIKE a gathering storm, each Soviet Success in the space/aero field has generated pressure in Washington for a "czar" who can resolve all issues and insure clear and undivided leadership for us.

Every so-called czar has moved into a Pentagon office with the promise of the three essentials — facilities, personnel, and money. And in a short while, he has discovered that to obtain them, he will have to infringe on another czar. That is because the fields are almost identical. They are based on the same space aeronautics technology, and require the same personnel and facilities to get the job done.

Here is a report on how the U.S. czar system has been operating:

(1) After U.S. radar tracking stations learned of successful Russian IRBM and ICBM firings, there was considerable excitement in the press and on Capitol Hill. Upshot was a Guided Missile Director, William M. Holaday, who was supposed to spark and coordinate America's ballistic missile effort. At the same time, each service had its own Assistant R&D Secretary responsible for ballistic and air-breathing missiles.

(2) After the launching of Sputnik 1, Holaday did not have enough glamour. The U.S. needed a new emphasis on space and ballistic missile de-

fense. Net result: Two czars. Roy W. Johnson moved in as Director of the Advanced Research Projects Agency, and Dr. James Killian became the President's Special Assistant on Science and Technology.

(3) But the space program could not be considered a strictly military program. Therefore the U.S. needed a civilian National Aeronautics & Space Administration (NASA), with Dr. T. Keith Glennan as Administrator.

(4) With reported Russian success on nuclear propulsion for aircraft, there will undoubtedly be a Congressional push for acceleration of our own efforts. Probable result—an A-plane czar.

(5) In direct conflict with all these czars is Donald A. Quarles, the Deputy Secretary of Defense. Quarles is a technical man whose past activities (as Secretary of the AF and before that as Assistant Secretary of Defense for R&D) have put him in the middle of most technical decisions involving new aircraft, missile and space projects.

The Department of Defense has never been able to exert a clear and unquestioned line of authority over the three services. Whenever the issue demanded a solution, the result has inevitably been one of compromise.

A reason is that at the DOD level, three mainstreams of Gov-

ernment converge — political, administrative, and strategic.

Public clamor demands a clear line of authority to get a job done, and the minute an appointment is made, there is a general effort to put the new man in harness—to make him conform.

Now comes NASA as a further complicating factor. Here the charter is clear. NASA was set up to boss the whole civilian space program — except that, at the very outset, it becomes apparent that the technology, facilities, equipment, and money are practically the same as in the military space program.

NASA top command sees the need for controlling the whole range of facilities that it needs to explore space and develop hardware, and indeed moved directly and vigorously in this direction.

The fact that some of the needed facilities, personnel, and money was controlled by the services did not deter NASA.

Result of the first round was a compromise. This has been the pattern in each of the past areas of issue. It is easy to rationalize the justice and wisdom of Caltech's Jet Propulsion Lab going to NASA and the Army keeping ABMA—but what happens with the long trail of compromises that already clutter up the picture?

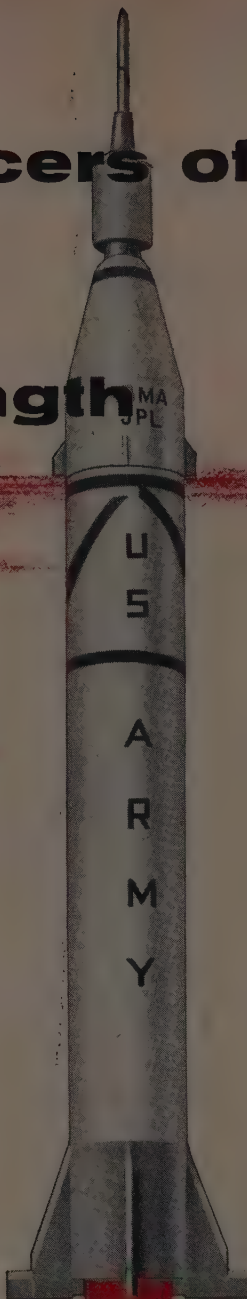
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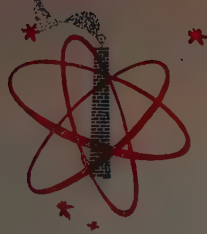
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Write in No. 284 on Reader Service Card at start of Product Review Section



by Robert M. Loebelson, Associate Editor

Are we really facing the Soviet threat?

AFTER THE RECENT Defense Department cutbacks and cancellations, several old-line aircraft firms are now fighting for survival—and they know it. Some of them may well disappear from the space/aero industry. Others will come through, though they will not be as important in the defense picture as they were only two or three years ago.

To Richard S. Boutelle, newly elected vice chairman of Fairchild Engine & Airplane, the recent cutbacks mean only that the Government has refused to face the facts.

"The military knew the ultimate cost of the defense program when it was laid out three years ago," he explains. "They knew a \$40 billion defense budget wouldn't cover all the projects they had underway."

Despite that, says Boutelle, the U. S. is maintaining a \$40 billion level—"even though we're in worse shape as far as the Russians are concerned than we were three years ago. And there is no such thing as being too well prepared if the Russians are really a threat. And if we don't have to worry about Russia, we ought to stop such a large defense program."

One thing that worries Boutelle is all the money spent on space projects. "Getting to the moon gets us on the front pages, but I don't know what good it does against Russia," he says. "If we had a really powerful defense structure, we could let Russia sit on the moon."

Boutelle believes that if we do need a large defense effort, we must spend enough to be fully prepared. "Couple the 15-minute warning time of ballistic missiles with not being prepared, and we're in a hell of a fix," he says.

A better system of defense production involves the proper dispersal of production facilities, Boutelle claims. "If we have a greater number of defense centers, the law of averages will provide a greater number of solutions if we are attacked."

He insists the government's policy now dis-



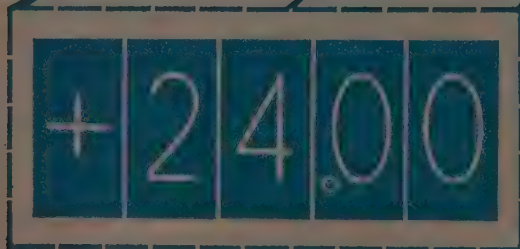
RICHARD S. BOUTELLE, vice chairman, Fairchild Engine & Airplane Corp.

counts the dispersal approach, even though that was considered an important element of our defense structure a few years ago. "Because of the squeeze from the Budget Bureau, the Defense Department is forced to focus on getting what the services want as fast as it can. This policy has resulted in the Defense Department's placing major orders with only a limited number of companies, most of them concentrated in one area."

The Fairchild executive concedes that the government cannot afford to support unqualified firms as defense suppliers. "But not all of the companies in trouble are unqualified," he adds. "How much of the various companies' present predicament is their own fault and how much is the Government's is hard to figure out."

Boutelle also points out that the present policy of letting some companies drop out of the defense picture has other shortcomings. "You tend to lose a fresh approach if some of the smaller aircraft companies go out of business."

Transistorized NLS M-24 Selected for Missile Checkout System



Analog to digital conversion in Nortronics' Universal Datico is accomplished by the ultra-reliable NLS M-24, the transistorized Digital Volt-Ohmmeter that automatically and accurately measures and displays AC and DC voltages, voltage ratio and resistance.

In Datico, program control is performed by a punched paper tape. Test stimuli are automatically controlled by Datico and output signals (voltage, voltage ratio, and resistance) from the system under test are automatically selected and fed to the NLS M-24. The M-24 digitizes the system outputs to 0.01%, and provides numerical data to the indicator and control chassis for distribution to the data recorder, digital comparator, and visual display on a special NLS in-line readout.

The tape also establishes the go-no-go limits for comparison with the M-24's digital output. It then directs the system to the next channel to be measured.

Operation of the NLS M-24 in this system is completely automatic . . . the instrument is remotely operable, does not require zero setting, and is extremely stable over very long time periods. Over-all system speed is not compromised by analog to digital conversion time, the M-24 making each measurement in just 330 milliseconds.

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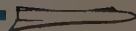


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DOD changes procurement plans as budget is squeezed

THE PENTAGON is still working on its decisions as to which weapon systems will be procured, which will be cut back and which eliminated entirely. Here is a rundown of what's been decided so far—more on the basis of budget restrictions than of technical inadequacies:

Orders for Convair's supersonic B-58 bomber were cut back from 47 to 36 for fiscal '59 funds. Thirty B-58s had been ordered with cash from prior years; an additional 40 will be procured with '60 money.

Production plans for the Chance Vought F8U-3 all-weather Navy interceptor were canceled. Three out of 18 F8U-3s ordered for evaluation have already been delivered.

NAVY DECIDED to buy the McDonnell F4H-1 (powered by two GE J79s), instead of the F8U-3, as the replacement for the McDonnell F3H-2 and Douglas F4D-1. The F4H-1 will carry four Sparrow air-to-air missiles, can also be fitted with the infrared Sidewinders.

USAF decided to buy more McDonnell F-101B Voodoo interceptors, to be delivered to the Air Defense Command through August '60.

Cancellation of Regulus II follows axing of F8U-3

MACH 2 REGULUS II ship-to-surface missile was dropped by the Navy. Chance Vought will be seriously hurt as a result of the Regulus II and F8U-3 cancellations. However, it still has a big production run scheduled for the F8U-2 Crusader carrier fighter.

NEW PROCUREMENT totaling \$50 million for Northrop's intercontinental, J57-powered SM-62 Snark surface-to-surface missile is planned by USAF. It insures Snark production through December '60.

Fairchild hoping for military orders on the F-27

FAIRCHILD'S GOOSE surface-to-surface decoy missile was cancelled by USAF, as was the company's J83 turbojet (which was to power the Goose). Fairchild now is left with only the commercial F-27 production line and subcontracts for the B-52G at its Hagerstown, Md., plant.

The company hopes USAF will order a military version of the F-27. A new \$11 million

subcontract from Boeing to make vertical fins, outboard wing panels, and fuselage sections for the B-52G will extend that job through June '60.

GE J83 jet gets go-ahead, but P&WA's JT-12 is still in the running

THE MAJOR COMPETITOR of the J83, GE's J85, was ordered into production by the USAF to power the new Northrop T-38 jet trainer. However, the JT-12, 2900-lb thrust light weight turbojet developed privately by Pratt & Whitney Aircraft, may still be selected as the powerplant for planes and missiles that need engines of this size—e.g., the T-38, North American's T-39 Sabreliner, McDonnell's Quail air-to-surface decoy missile. Lockheed's JetStar, and Northrop's N-186F all-weather fighter (for possible NATO use).

BELL GAM-63 RASCAL air-to-surface missile was dropped—after USAF had spent about \$374 million to develop it for the B-47. The project is not considered a complete loss, because the liquid rocket Bell designed for the Rascal will be used in the top stages of forthcoming space vehicles.

PROCUREMENT of Martins' P6M SeaMaster flying boat was cut back from 24 to 14—which will be all the P6Ms the Navy intends to buy.

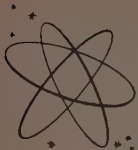
CONTINUED PROCUREMENT is slated for both Atlas and Titan ICBMs. Titan malfunctioned at its first firing at Cape Canaveral and was shipped back to Martin-Denver for modifications. But USAF is still convinced it will be needed as a backstop for Atlas.

Jupiter vs Thor decision now hinges on NATO

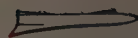
DEFENSE SECRETARY Neil McElroy once again deferred the decision between the Thor and Jupiter IRBMs—pending word from NATO nations. Britain is already getting Thors and Italy Jupiters, and the U. S. hopes France and other nations will also accept the missiles. . . . Most probable result—neither Thor nor Jupiter production orders will be cancelled. But any follow-on contracts will go to Douglas for the Thor.

SOVIET RUSSIA WILL HAVE 300 ICBMs with a range of 5000-8000 miles within 18 months, according to a study by the Council on Foreign Relations. The Council is convinced half of these

more on page 24



technical management intelligence



missiles could be expected to operate reliably and hit within three miles of their targets.

Any Soviet attack involving 150 ICBMs with hydrogen warheads would cripple either our productive capacity or at least the Strategic Air Command. . . . Probable result of the Council's findings—little action to step up procurement of U. S. ICBMs and almost no change in the development program for the Zeus-Wizard anti-missile missile project.

White House science advisor to be advised by interdepartmental group

NEW FEDERAL COUNCIL for Science and Technology was set up by President Eisenhower to his science advisor, Dr. James R. Killian, Jr. It will recommend "policies which will improve the planning and management program, . . . facilitate the resolution of common problems," and "promote . . . interagency coordination."

Eisenhower acted after his Science Advisory Committee had rejected a proposal for a department of science with cabinet status. The Committee said such a department was not a good idea because the government's scientific work is either too closely related to the missions of the existing departments that carry it out (as in DOD's case) or too specialized (as in NASA's case).

The Federal Council for Science and Technology will meet the nation's needs better, the Committee stated. Its members will represent all Government agencies with scientific and technological interests. Dr. Killian will preside over the new council.

R&D procurement philosophy under scrutiny

IS THE GOVERNMENT spending too much of its R&D money on the outside? A "critical examination" of policies and practices on R&D under Government contract was recommended by the Science Advisory Committee.

The group notes that the percentage of R&D money spent outside the Government is mounting steadily. It points out that by '62 two out of every three Federal R&D dollars will go to private organizations.

ANOTHER AREA that bothers the Science Advisory Committee is the "serious underinvestment" on RD. Programs in many fields are handicapped as a result.

A contributing factor, the Committee found, is that, as Federal support of scientific programs grows, "corporations and private foundations [hesitate somewhat] to maintain the level of their contributions to scientific research in academic and other non-profit institutions."

Contractor's lot would be easier under proposed legislation

SEN. LEVERETT SALTONSTALL's proposals to modify DOD procurement policies are now considered generally satisfactory to the individual services and AIA. The Massachusetts Republican, ranking minority member of the Senate Armed Services Committee, first introduced his procurement legislation last August in the 85th Congress—which did nothing about the matter: He has now reintroduced the measure with many changes after consulting with DOD and AIA officials.

IF SALTONSTALL's major proposals are adopted, these would be some of the results:

- All major weapon systems could be placed under a single weapon system manager with complete responsibility for the project. (Originally, Saltonstall wanted this clause to be mandatory.)
- Negotiated contracts would be as legal as those awarded after formal bidding. (Negotiated contracts now are permissible as exceptions when advertised bidding is impractical.)
- Incentive and fixed-price contracts would be exempt from renegotiation.
- Contractors would have to pay for engineering advice received from the U. S. (DOD officials feel this advice should be free.)
- "Performance" specifications would suffice in place of the "elaborate detailed specification" now required.

Forecasts of USAF's material needs to be put on more scientific basis

AIR FORCE OFFICIALS are working up a program for predicting what new metals and other materials will be required for aircraft and missile programs a decade from now. They want to prevent a recurrence of past situations in which required materials were not ready for production. Titanium is a prime example.

The Materials Advisory Committee of the National Science Foundation is working with USAF on this project. Other groups on the project in-

more on page 26



Preloading of the New Departure double row ball bearing eliminates progressive fretting corrosion problem induced by engine vibration.

Photo: Courtesy Warner Electric Brake & Clutch Co.

N/D *Preloaded Double Row Bearings Solve Fretting Corrosion Problem In Electric Clutch!*

CUSTOMER PROBLEM:

Fretting corrosion of automobile air conditioner electric clutch bearings due to engine vibration. Application requires compact bearing design and positive lubricant sealing.

SOLUTION:

N/D Sales Engineer, working with the manufacturer, suggested replacing two single row bearings with one internally preloaded New Departure Double Row ball bearing with shield and Senti-Seal. The preloaded angular contact construction of these New Departures offered maximum resistance to combined radial and thrust load deflections, plus freedom from

effects of engine vibration. Problem of fretting corrosion was eliminated by producing bearings with accurately determined internal compression. Lubrication of bearing was assured for life by New Departure's exclusive Senti-Seals . . . dirt was sealed out under extremely contaminating conditions. In addition, the compact size of these double row bearings eliminated a tough assembly problem . . . and provided savings in both space and costs.

When you're faced with a bearing problem, why not call on New Departure. Chances are there's a precision N/D high production bearing that will solve it. For more information, write Department H-2.

Available through United Motors System and its Independent Bearing Distributors.



NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Write in No. 286 on Reader Service Card at start of Product Review Section



clude Battelle and the Woods Hole, Mass., Summer Study Conference.

ONCE USAF has determined its future materials needs, the problem will be turned over to the Air Material Command's manufacturing methods organization. This group will work on the producibility bugs to make sure the materials are available on time and at a reasonable price.

NASA INVENTIONS & Contributions Board will provide financial and other credit to inventors who supply the U. S. with devices to speed progress toward the space age. The Board will recommend rewards to inventors and waivers of the U. S.'s title to inventions made under NASA contract.

The Board is charged with evaluating "any scientific or technical contribution" to NASA which may have "significant value in the conduct of aeronautical and space activities"—regardless of whether it can be patented or was conceived under NASA contract. It may recommend to T. Keith Glennan, head of NASA, that he make monetary awards for such contributions.

IN DECIDING ON AWARDS, Glennan, must take into account, among other points, the "sums . . . expended by the applicant for the development of [his] contribution." Any award exceeding \$100,000 may be made only after Congress has been given a complete report.

TWO HIGH-RANKING Pentagon officials will have even more important voices in the future activities of the space/aero industry after their recent promotions. Garrison Norton, whose job as Assistant Secretary of the Navy for Air was abolished by Congress, now is in charge of the hush-hust Institute for Defense Analysis. Formerly headed by Dr. Killian and then by Dr. Glennan (now NASA Administrator), IDA was set up by several top-ranking universities to help formulate our defense program. Many of the people in ARPA are still connected with IDA.

Much wider powers for Dr. York in new job

ARPA'S CHIEF SCIENTIST. Dr. Herbert F. York, became Assistant Secretary of Defense for Research and Engineering. He is expected to have much wider powers than his predecessors in a roughly comparable job also abolished by Congress. However, his exact relationships with ARPA Director Roy Johnson, Guided Missile Director William Holaday, and other Pentagon "czars" are still to be spelled out.

SPACE PROJECTS will contribute to our standard of living as well as to our security, according to ARPA Director Roy W. Johnson. He believes satellites will ultimately provide navigation systems for aircraft, ships, and space vehicles. Among the areas in which space research will pay off, he says, are:

- propulsion systems;
- small, light power packages (including nuclear types);
- weather forecasting—within a decade, satellites will be able to detect storms, tornadoes, hurricanes, and other weather phenomena at a cost of about \$25,000 a day;
- communications—with satellites using 100-W power, and would circle the earth every 24 hours at 22,000 miles;
- television—with relay satellites for transmission between cities.

No additional funds are required to accomplish these non-military projects, Johnson says. About \$1 billion, including \$700 million for research, will be expended in '59 on spade work, he reports.

Accessory system firms may get more responsibilities

ENVIRONMENTAL control systems for North American B-70 bomber and F-108 interceptor will be developed and built by Hamilton Standard. They will pressurize and automatically cool or warm the crew quarters and the electronic equipment compartment. . . . The increasing complexity of future weapons systems should lead to more cases in which complete subsystem responsibility on a program is given to an accessory system company.

U.S. ADOPTED international measurement standard for the inch making it equal to 25.4 mm. To avoid confusion during the transition period to this standard, NBS will call attention to the use of the new standard whenever it involves a significant difference in calibration values.

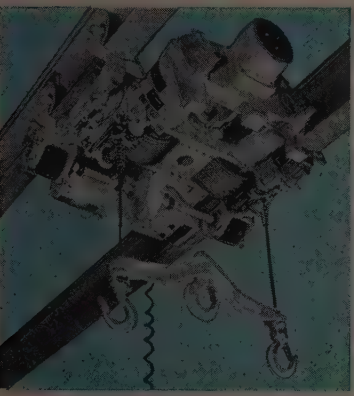
INTERNATIONAL INCH is about two parts per million shorter than NBS' present inch. It is somewhat less than two parts per million longer than the inch now used by the National Physical Laboratory.

INTERNATIONAL STANDARD was agreed upon by Australia, Britain, Canada, New Zealand, South Africa, and U. S. . . . Scientists are talking of swinging over to the metric system for all "space" projects. Transition would be easier if made right now, since it would not require drastic revisions of existing references and designs.



HIGH SPEED HANDLING

FLY-AWAY HOIST SPEEDS JET TRANSPORT



This compact, powerful fly-away hoist for the KC-135 lifts an 8,000 lb. load at 10 or 20 fpm... moves it in the plane at 20 or 40 fpm.

Typical of WESTERN DESIGN'S 13 years' specialized experience in aircraft cargo hoisting, transversing and airline baggage lifting, the KC-135 hoist is one of many systems designed and produced for applications which include helicopter rescue, sonar hoisting, litter lifting, bomb and missile loading, fuel hose retraction, and delicate instrument handling. The DC-8, 707, KC-135, B-52, C-124, KC-97, C-47, C-46, DC-6, and RC-121 are equipped by WESTERN DESIGN.

For any cargo hoist requirement, ground or air, call WESTERN DESIGN.

USI Western Design

DIVISION OF U. S. INDUSTRIES, INC.

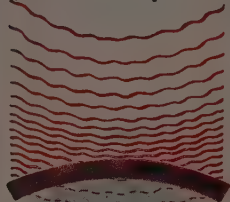
Santa Barbara and Montebello, California

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Santa Barbara Airport • Goleta, California • WOODLAND 7-4571

Johns-Manville announces new **MIN-KLAD** Insulation!

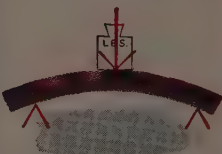
This one new product answers 4 basic thermal and mechanical requirements



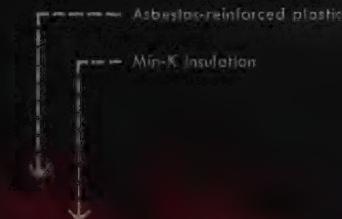
low conductivity



high heat capacity plus erosion resistance



high strength



New Min-Klad insulation is engineered and molded to your design requirements.

Combines the capabilities of asbestos-reinforced plastic with the dramatically low conductivity of **MIN-K** insulation!

New Min-Klad insulation may well be the most significant advance ever made in missile and rocket insulation.

Developed by Johns-Manville research scientists, Min-Klad is the only product of its kind, a permanent lamination of the missile industry's two most effective high-temperature materials: 1) reinforced plastic and 2) J-M's recently developed Min-K insulation.

Does more than plastic alone

Min-Klad gives the missile designer all the advantages of high-temperature plastic: Strength, toughness, rigidity! Erosion resistance! High heat capacity! Yet Min-Klad does more.

It also insulates . . . and with dramatic effectiveness! Its insulating element is J-M's Min-K, an insulation with thermal conductivity that is lower than any other known insulation. Actually

lower than the molecular conductivity of still air. And this conductivity (already less than half that of the best fibrous insulations) drops still further with altitude. At 10 miles, for example, it is decreased by as much as 40%, with further decreases at greater altitudes.

Wide range of applications

Min-Klad offers the missile and rocket designer a rich choice of heat-control possibilities. It may be used for a part that must insulate, yet have the structural advantages of plastic. Where requirements call for a scuff- and erosion-resistant insulating surface . . . or for a good adhesive bond between Min-K insulation and other surfaces. Or, it may be used to control high transient

temperatures! For high heat capacity of asbestos-reinforced plastic combined with the low conductivity and heat capacity of Min-K result in a product that provides minimum heat transfer under transient conditions.

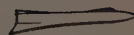
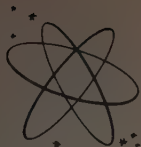
Min-Klad is now being tested for approximately two dozen missile and rocket designs. Why not investigate this new material for your present thermal requirements? Upon request, we'll be pleased to send you a sample of the material along with detailed technical information. Write Johns-Manville, Box 14, New York 16, New York. (Ask, too, for information on Min-K insulation and the new aviation insulation brochure IN-185A.) In Canada: Port Credit, Ontario.

JOHNS-MANVILLE



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SPACE/AERONAUTICS



Prototype of 1,500,000-lb thrust engine by mid-sixties

FOLLOWING UP USAF's earlier feasibility study contract, NASA has picked Rocketdyne to design and develop a single rocket delivering 1-1.5 million lb of thrust. Six firms had submitted entries in the NASA competition. Total cost is expected to exceed \$200 million.

Rocketdyne is also working on an Army contract to get the same thrust by clustering about eight engines similar to those used on Thor, Jupiter, and Atlas (at about 135,000 lb thrust per engine).

NASA ENGINE will take 4-6 years to reach the prototype stage and cost about \$200 million. . . . By then the long term biomedical problems of space travel should be far enough advanced for the engine to see early service in manned satellites.

Precise guidance brought Lunik very close to moon

RUSSIAN LUNIK, or Mechta, space vehicle entered a solar orbit outside that of the earth and will never return to earth. Guidance accuracy was good enough to make the craft pass within 4660 miles of the moon.

The artificial planet will take 15 months to complete its solar orbit. It is expected to be farthest from the sun (123,254,000 miles away) at the beginning of September.

LUNIK's total launching weight must have been about 250 tons. Juno rocket used in our Pioneer moon shots weighed about 50 tons.

Lunik wasn't quite fast enough for a Mars orbit. According to calculations made by Krafft Ehrlicke, its maximum velocity came to 106,200 fps. To reach Mars—141,500,000 miles from the sun—it would have had to travel 110,000 fps or more.

Red Venus launch forecast for this summer

RUSSIANS' SUCCESS indicates they could launch a good-sized vehicle toward Venus this June. Ehrlicke estimates they could send up a payload of 500-700 lb.

LUNIK'S PAYLOAD contained instruments for eight different experiments and measurements. Three radio transmitters broadcast the results in a coded, high-pitched whistle.

Soviet astronomer Boris Kukarkin said Lunik sent back data on the moon's magnetic field, geological surface, and radioactivity.

LAUNCHER FOR LUNIK undoubtedly was the same as for Sputnik III. Russians must have done the obvious—converted Sputnik III's 3000-lb payload into a new, 3245.2-lb third stage for Lunik (see *Sideviews*).

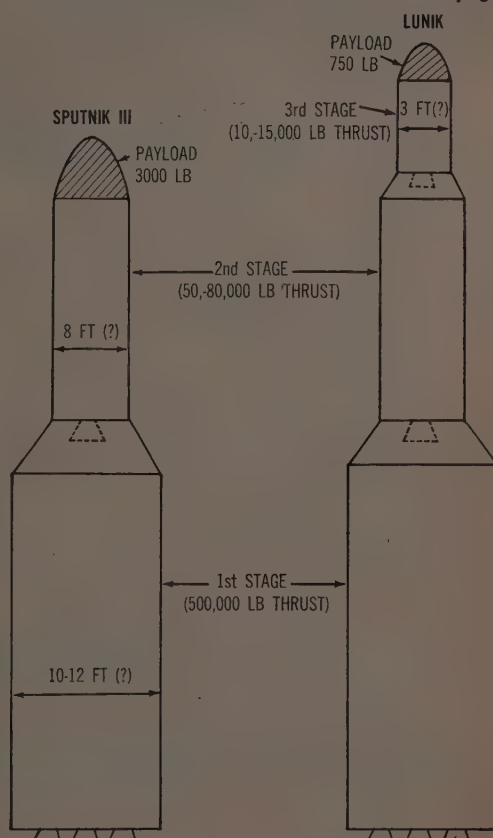
Payload was cut to 796.5 lb for Lunik. Taking separation and attachment fittings into account, this leaves about 2000 lb for the last-stage rocket. Eight to ten feet long and burning hydrogen peroxide and kerosene, this engine probably had a thrust around 15,000 lb.

Lunik's burning time: 330 sec

COASTING-TIME COMPUTER and precise autopilot probably were used to guide the last Lunik stage.

Lunik's burning times must have been something like 150 seconds for the first stage, 120 seconds for the second, and 60 seconds or so for the third and last.

more on next page





NAVY IS STEPPING UP underwater studies. Three oceanographic ships have been assigned to make a three-dimensional chart of the ocean and its floor. . . . One reason for this project might be that the Navy hopes to use ocean floor "landmarks" as reference points for trajectory computations for underwater-launched ballistic missiles.

CHROMIUM-NICKEL COATING to keep molybdenum from oxidizing has been developed by National Bureau of Standards for BuAer. It remains effective for over 1000 hours at 980 deg C and for over 300 hours at 1100 deg C.

FIRST STEP in plating process is to etch the molybdenum with a 1:1 solution of concentrated sulfuric and phosphoric acids. After that a one-mil chromium deposit is electroplated on the molybdenum at 85 deg C and 120 amp/dm². The newly plated surface is again etched, this time with a 1:1 hydraulic acid, given a nickel strike, and plated with seven mils of nickel.

Powered by liquids and solids, Aerobee sends 65-lb payload up to 260 miles

NEW AEROBEE 300 sounding rocket carried a 65-lb payload up to 260 miles. It is designed to send a payload of 50-lb up to 300 miles. It has a standard Aerojet 2.5KS-18,000 solid propellant booster with an Aerobee-150 liquid propellant first stage and a 1.8KS-7800 solid propellant second stage.

IRON-ALUMINUM-MANGANESE alloy developed by National Research, Cambridge, Mass., is said to look good for high temperature use. Most promising composition is 10 per cent aluminum, 34.4 per cent manganese, 0.76 per cent carbon, and the balance iron.

New steels are austenitic. They are about 15 per cent lighter than carbon steel or 18-8 stainless and 20-25 per cent lighter than the cobalt- and nickel-base super alloys. They show improved strength even over 1200 deg F, yet are ductile at room temperature.

Delta drone jet to fly surveillance missions for Army

SD-4 SWALLOW surveillance drone is a pilotless jet aircraft. Republic Aviation's Army contract for \$25 million calls for detail design and production of both the drone and the ground control units — including airframe, guidance controls, surveillance data presentation and reduction, and transport vehicle and launcher.

The Swallow has a delta wing spread of 11 ft. Surveillance missions can be carried out by a pre-programmed automatic guidance system or by air or ground control systems.

Cheaper sandwich construction through use of electric resistance welding

ELECTRIC resistance welding technique developed by Republic Aviation for fabricating corrugated sandwich panels is accurate to 0.003 in. overall thickness. Sheets as large as 16 sq ft have been made. According to Adolph Kastelowitz, chief of manufacturing R&D, the corrugated panels are as much as 75 per cent cheaper than earlier types of sandwich construction, which use a honeycomb filler.

SECRET FUEL EXPLOSION that killed three engineers at Callery Chemical's plant in Lawrence, Kan. resulted from an unauthorized experiment. A fuel and oxidizer combination, loaded into a rocket chamber, exploded prematurely. The oxidizer was magnesium perchlorate—the fuel remains classified.

New filter stops fuel icing, is specified for B-52 and DC-8

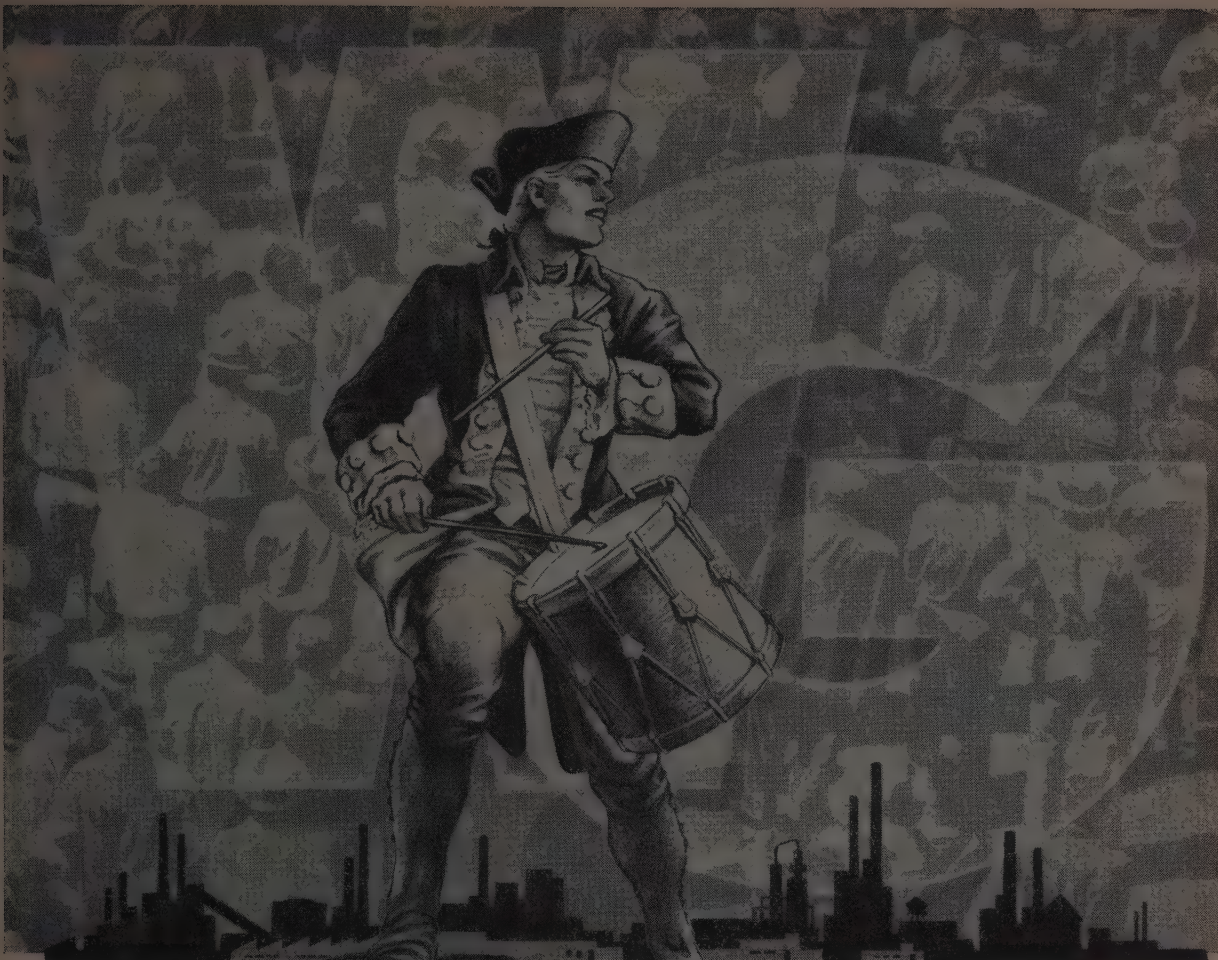
SERIOUS JET FUEL ICING problems are solved by the new Perma-Dry filtering unit, an emulsion breaker designed by Permanent Filter, Los Angeles. The jeep-mounted unit will be used with B-52s under an AF contract.

Present Perma-Dry unit decontaminates fuel at 600 gpm. A 2000-gpm unit is being designed. Water is removed to a point 10-15 ppm below the fuel's solution level. Other contaminants down to ½-micron size are also removed.

Douglas has specified Perma-Dry for DC-8 fueling. Use of this equipment on jets operating above 30,000 ft for several hours, eliminates wing heaters.

TEMPERATURE control system for Army's Grumman Mohawk turboprop observation plane is being produced by Hamilton Standard. Warm air siphoned off the engine heats both cabin and camera compartment. System weight of 13¼ lb is about 50 per cent below that of other systems of this type, according to Ham Stan.

more on page 32



the spirit of 76...

THE SPIRIT OF '76 . . . exemplifying strength—dependability—determination to move forward through the years.

Wyman-Gordon enters its 76th year still forging ahead with new forging techniques—still meeting the challenge of the seemingly impossible in this age of power and speed on the ground—in the air—and in outer space.

It is a far cry from the modest beginning in

1883 to the forging industry's most modern testing and research facilities in the extensive laboratories of Wyman-Gordon today—assurance of the ultimate in forging quality.

From the high wheel bicycle through the “horseless carriage” days to the “Mach era” of aircraft and space vehicles, Wyman-Gordon has marched under the standard of “The Greatest Name in Forging.”

WYMAN-GORDON COMPANY

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FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

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SOLAR SAIL VEHICLE proposed by Los Alamos Scientific Lab could carry a 25-lb payload. The disk-shaped sail would be folded up inside a space probe for launching. It could be opened in space upon ejection by either spinning it as it is released or by pressurizing hollow telescoping ribs. Open sail would be about 350 ft in diameter and weigh 25-30 lb.

The sail would be made of a thin plastic film coated with evaporated aluminum. Pressure of solar radiation — only about 1/100 lb/acre on earth — would be enough in space to maneuver a vehicle around the earth and into the gravitational pulls of other planets.

To Mars and back in three years with 1000-lb, ¼-mile-wide sun sail

THE "SAILING SHIP" would start out as a satellite orbiting around the earth. The sail would travel edgewise as it moves toward the sun and fully exposed to the sun's rays as it moves away from the sun. Radio command signals from earth would be used to adjust the attitudes of gyros attached to the sail. . . . Where the gyros would get their power is not clear — perhaps from a solar battery jib or spinnaker.

Maneuvered by its solar sail the space ship could be driven into an orbit around the sun. Los Alamos scientists figure a sail weighing 1000 lb and about ¼ mile wide could navigate to Mars and return to earth in less than three years.

GOOD LAUNCH OPPORTUNITIES are limited for Venus and Mars ships. Calculations show we could have only four good shots at Mars within the next 10 years and only six at Venus.

In June, Venus will be in a favorable position for an earth launching. The first Mars opening will come in August—with the second not due until September '62. (See also "How Feasible Are Mars and Venus Probes?" p. 46).

First solid data on radiation belt's energy levels through chance recording

UNEXPECTED PAYOFF has been reaped from Pioneer III data. By chance the Puerto Rico tracking station was in contact with the probe on the upward leg into the radiation belt and during the descent. Telemetry tapes for both phases show

solid data that for the first time give information on some of the energy levels in the radiation belt as well as on the belt's physical limits.

Pioneer's temperature control troubles didn't recur

PIONEER III's temperature control is reported to have worked perfectly. Telemetry shows temperature reached 43 deg C shortly after launch and stayed there throughout the probe's life.

EXPLORER EXTERIOR was striped with zirconium oxide to control absorptive and radiative heat effects. Black and white pattern was painted over the gold-plated skin to help stabilize internal temperatures. Proportion of painted to unpainted surface varied from 15 to 44 per cent at different stations. (See *S/A, Honeycomb Housing for Pioneer Instruments*, Jan. '59, p. 178.)

Measurements of millionths of a second needed for far space launchings

EXACT TIME REFERENCES are critically important for far space launchings, such as to Mars or Venus. Time will have to be measured to millionths of a second. (Till now thousandths of a second have been good enough.)

The atomic clock looks like the answer. Several groups are reported to be working on atomic clocks that use the decay of atomic particles as a measure of time. Expectations are that they will be able to measure time down to 10^{-7} seconds

Lockheed says scientific lab 500 miles in space is feasible

SCIENTIFIC SPACE LAB to be built 500 miles above the earth was proposed by Lockheed Missile Systems—as a practical project. The orbiting research facility could also serve as an advance base for space exploration.

The proposal is based on existing concepts. Lockheed claims space technology has advanced so rapidly that time is ripe to give "practical and realistic consideration to a detailed plan" for a space lab. If the go-ahead for the project were given today, Lockheed engineers say the station could be in operation within 10 years.

more on page 34

Write in No. 290 on Reader-Service Card→
SPACE/AERONAUTICS



59-5

This is the first space that must be conquered

Two thousand years ago Lucan wrote about a trip to the moon. Today, the two thousand years of dreaming he inspired are close to fulfillment.

Experience in building things from dreams has always been part of Ex-Cell-O. Precision in design, precision in manufacture for forty years has been the Ex-Cell-O tradition. Now as we near the conquest of space, even more important becomes speed of translation from dream to reality. And for this Ex-Cell-O's history and facilities are yours for the asking.

EX-CELL-O FOR PRECISION



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*Aircraft
Division*

MAM AND MISSILES FLY HIGHER, FASTER AND SAFER WITH PARTS AND ASSEMBLIES BY EX-CELL-O AND ITS SUBSIDIARIES: BRYANT CHUCKING GRINDER CO., CADILLAC GAGE CO., MICHIGAN TOOL CO., SMITH BEARING CO.



Lab's prefab parts would be assembled in space

CELESTIAL LAB would carry a 10-man crew and weigh 400 tons. It would be made up of prefab units assembled in space within less than a week. From initial launch to operation of the fully assembled lab, 12-30 days would elapse.

The lab station in the end would be a 94-ft, wheel-shaped satellite. It would consist of 15 cylindrical compartments in the rim, five spokes, and three hubs. Each unit would be launched separately by a three-stage ballistic missile and be guided into a cluster on the same orbit.

RIM COMPARTMENTS would each be 20 ft long, 10 ft in diameter, and weigh 10 tons stocked. The rim would contain living quarters and workshop and support areas.

The central control hub would contain a medical lab, an astronomical and weather observatory, and a central power control for all the major systems aboard the satellite.

INITIAL CREW would include an astronomer, two physicists, a chemist (who would double as a photographer), a biologist, two electronic engineers, a metallurgist and machinist, and two physicians.

A crew of ten could live without additional supplies from earth for more than six months. With a supply line to earth, they could stay up indefinitely.

HIGHER PRODUCTION RATE for North American's T2J jet trainer and its Westinghouse J34-WE-46 engine was ordered by the Navy. J34 deliveries will continue through the middle of '60.

Lobber cargo missile carried 50-lb payload over a six-mile range

CONVAIR'S LOBBER, forerunner of what may ultimately become a new form of transport for the military services, was successfully fired for the first time at Camp Irwin, Calif. It carried a 50-lb payload intact over a six-mile range.

The nine-foot solid-propellant missile can travel at up to 1500 mph. It uses a portable launcher, which can be carried by three men. Convair sees it as the prototype of a much larger missile that will haul fuel, munitions — and perhaps even troops.

WEAPON SYSTEM 199B, USAF's designation for its airborne solid propellant IRBM, is making

steady progress. Martin, which has one of the WS-199B contracts, has been testing its two-stage Bold Orion at Cape Canaveral in drops from a B-47. One test vehicle traveled 1000 miles.

Lockheed's ALBM (Air Launched Ballistic Missile), entry for the WS-199B is partly based on the experimental X-17. It has gone at least 300 miles after being launched by a B-58. It weighs about 3.5 tons, is about 25 feet long, and travels at up to Mach-10.

Integration of Bomarc missile into Sage system should cause no problems

GOOD REPORTS of continuing tests of the Sage-Bomarc system—following a successful intercept controlled from a base 1500 miles from the launch point—show the Boeing missile will probably integrate smoothly with the complex air defense system. The system consists of the missile itself and two basic ground units—a giant IBM Sage computer and a search and height-finding radar. The last has a built-in data processor whose output (coordinate data) is transmitted to the computer over leased telephone lines.

FIRST PRODUCTION CONTRACT for Army's Sergeant missile went to Sperry-Rand's Utah Engineering Lab in Salt Lake City. It comes to about \$22 million—for continued development as well as production of an unspecified number of missiles.

In over 25 operational field launchings of the Sergeant so far, there hasn't been a single failure.

Successors of Hound Dog and Bullpup among 1959's big missile projects

ARMY'S Red Eye and Mauler, Navy's Eagle and Atlantis, and AF's Bold Orion and White Lance should be among the "big name" missile projects of '59.

The Eagle is an air-to-air fleet early warning defense system that reportedly uses radar guidance and an infrared fuzing system. The air-launched Bold Orion is slated to succeed the jet-powered Hound Dog. Also air-launched, the White Lance, successor to Bullpup, has TV guidance, with a scanner-transmitter in the bird and a receiver-monitor in the carrier aircraft.



The new Navy method of basic jet training

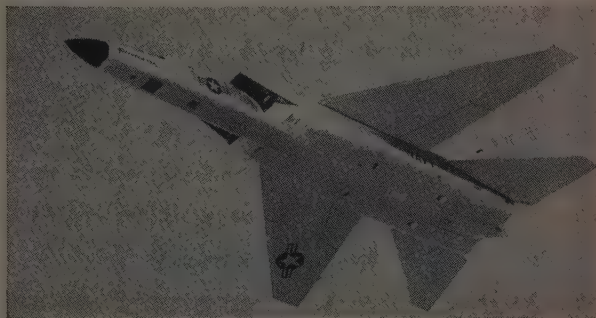
North American Aviation's model T2J is an airplane conceived and created to meet every requirement of Navy basic training. The student stays with the same airplane from primary through basic, including instrument flying, armament handling and tactics, combat maneuvers, and an early introduction to carrier work. On completion of Navy basic training, he will be thoroughly conversant with all phases of jet operation up to high Mach numbers.

Performance with safety. The T2J's stall speed is only slightly above that of piston trainers. Top speed is 424 knots, and safe dive speed has been demonstrated at Mach 0.85. Endurance without external fuel is about 1½ hours. Two 100-gallon wingtip tanks give the T2J a range of over 800 nautical miles.

Simplicity of maintenance. The T2J has large, quick-opening access doors for waist-high engine maintenance; no stands or ladders needed. Ground handling and servicing can be done with standard field equipment. All equipment and systems are easily accessible.

The T2J's powerplant, the Westinghouse J-34, has been removed in seven minutes, installed in twenty.

In production now. The T2J is now in full production at the Columbus Division of North American.



Double-threat weapon system. The A3J Vigilante, designed and built for the Navy by North American, is one of the world's fastest planes—yet unique aerodynamic and armament control features give it excellent low-altitude capability for attack bomber missions and landings on carrier decks and short runways ashore. An extremely accurate bombing-navigation system pinpoints the A3J's targets in any weather. And it can deliver every kind of weapon, including nuclear.

THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.

Columbus, Ohio



Write in No. 36 on Reader-Service Card

How Titanium

licks the weight bogey in components . . . A STUDY IN MACHINING SUCCESS

Today's aircraft component manufacturers are getting squeezed from two directions: Weight allowances of complex parts are being drastically reduced . . . but redesign costs to shave off a few ounces of excess "fat" cannot be written off in the short-run orders of the current market.

What can the manufacturer do? Should he trade profit for good will, or should he simply give up, and yield his position in a market with such excellent potential?

Titanium Metals Corporation of America has found increasing case-history evidence that an economically sound compromise exists: Substitution of titanium for heavier materials, on a volume basis. The results: a lighter assembly; elimination of redesign costs; and no extensive equipment purchase or modification.

Best news of all, the finished product can be marketed competitively. Here's the proof:

There's an old chestnut, held over from several years ago, that titanium is next to impossible to machine. This belief goes back to the time when fabricating techniques for this new material were still being developed. Today, though, the picture has changed:

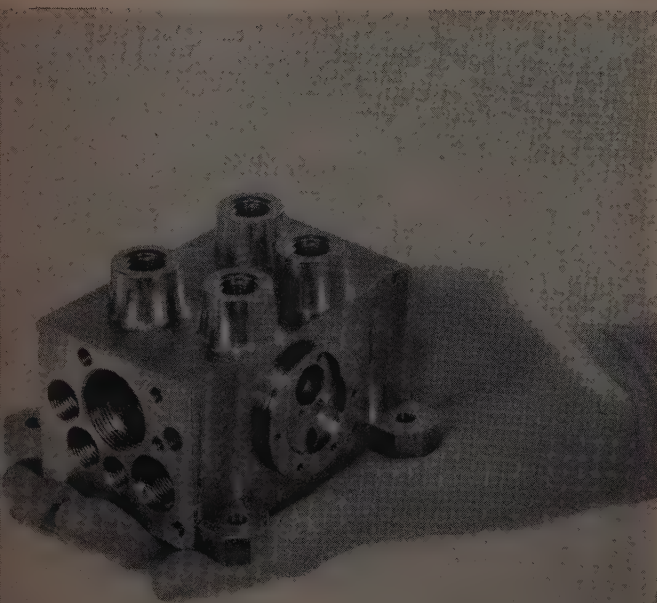
"... prefer machining titanium to ... stainless steel ..."

Cadillac Gage Company, Warren, Michigan, has substituted Ti-75A titanium for a high-nickel alloy in valve housings designed for North American Aviation's A3J Navy attack aircraft.

Titanium *combines* the properties that ordinarily require a series of materials. Lightweight titanium is non-magnetic, corrosion-resistant and retains its great strengths from -300°F to $+1000^{\circ}\text{F}$. What does titanium mean to Cadillac Gage in production of valve housings?

Weight saving: $2\frac{1}{2}$ lb. Size of contract: \$100,000.

Project Engineer Robert Moffatt states: "Our shop personnel actually prefer machining titanium to some grades of stainless steel. And the use of titanium has added no more than 5% to 10% to the final cost of the valve."

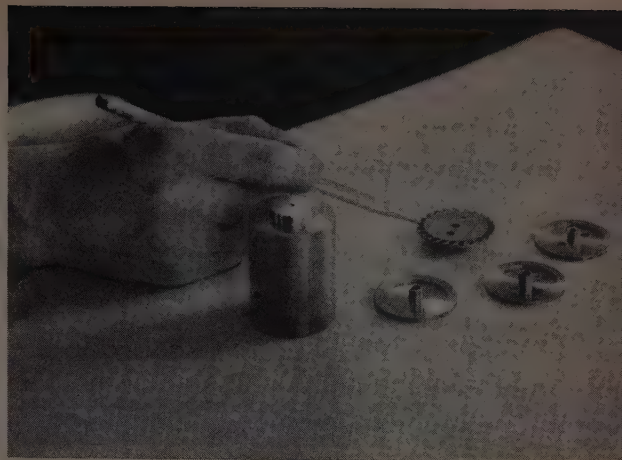


ease in machining . . . competitive with plastics . . .

Fischer Machine Company, Philadelphia, Pennsylvania, machines titanium on conventional equipment, holds tolerances to 0.0002" on 1/2-ounce turbine wheel 1 3/4" in diameter, has contracts for \$60,000 in titanium parts.

The turbine wheel, which actuates the generator in Philco's 155-pound Sidewinder missile, reaches speeds of 60,000 rpm. in a fraction of a second. The application calls for a low density material with great strength and heat resistance. Fischer employs annealed Ti-6Al-4V (130,000 psi tensile; density 0.163 lb./cu. in.) for the job.

General Manager John Sutton says: "Recent price reductions and our ease in machining have combined to make the prices of our turbine wheels competitive with machined plastic wheels. There is, of course, a price difference — but that's more than settled by titanium's vastly superior performance."

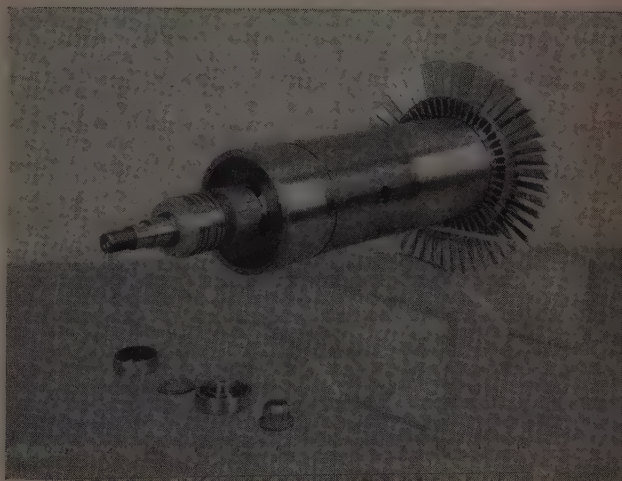


titanium helps hold rotor weight to 20 pounds . . .

General Electric Company, Lynn, Massachusetts, has introduced a new concept in electrical power generation which combines the generator and turbine into a single self-cooling unit. It's called the Turbonator.

Turbine and rotor — both on a common shaft — operate at 24,000 rpm. Titanium substituted for steel in top sticks and retaining rings enables GE to hold rotor weight to 20 pounds, and achieve efficient turbine speeds, because non-magnetic titanium can withstand high centrifugal forces.

John W. Harrison, project engineer, reports: "The Turbonator cuts package size 50% and cost 20% from conventional turbine-generator systems. It's versatile and can be used anywhere there's a jet engine."



These findings highlight two things: the growing concern of airframe makers over weights of purchased parts; the feasibility of constructing with titanium, instead of redesigning to combat excess weight.

The key to effective use of titanium lies in overcoming ingrained fears relative to machining.

For example, titanium has a low work-hardening rate, low coefficient of friction, low shearing force and freedom from notch sensitivity — all contributing to its relatively good machinability.

Commercially-pure grades (Ti-55A, Ti-65A, Ti-75A) in general, machine similar to the 300-series of stainless steel. Alloy grades (Ti-6Al-4V, Ti-7Al-4Mo, Ti-155A, Ti-5Al-2.5Sn) are similar to the 400-series.

Use of sharp tools (replaced at first signs of wear), high feeds, slow speeds, and liberal amounts of coolant enable fabricators to achieve economical production runs.

Titanium Metals Corporation of America is always ready to help you take full advantage of titanium's excellent combination of design properties, by providing a steady flow of information on fabrication techniques,

and maintaining a referral program by which prime contractors may locate component manufacturers of demonstrated ability.

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calendar

February 3-5—14th Annual Technical and Management Conference, Reinforced Plastics Division, Society of the Plastics Industry, Inc., Elmhurst Water Beach Hotel, Chicago.

February 12-13—1959 Solid State Circuits Conference, Institute of Radio Engineers' Professional Group on Circuit Theory, American Institute of Electrical Engineers' Committee on Electronics and University of Pennsylvania, Philadelphia.

February 12-13 — Computer Data Processing in Industry, conference for manufacturing and engineering management, Purdue University, Lafayette, Indiana.

February 23-26 — Symposium on Thermophysical Properties, American Society of Mechanical Engineers, Purdue University, Lafayette, Indiana.

February 26-March 1—1959 Engineering Exposition, Balboa Park, San Diego, Calif., inquiries: 414 Land Title Bldg., San Diego, Calif.

March 3-5 — 1959 Western Joint Computer Conference, IRE, AIEE, Assn. for Computing Machinery, Fairmont Hotel, San Francisco, Calif.

March 5-6—Flight Propulsion Meeting (classified), Institute of Aeronautical Sciences, Hotel Carnegie, Cleveland, Ohio.

March 5-7 — Western Space Conference and Exhibit, Information Domestic Trade Dept., Los Angeles Chamber of Commerce, 404 S. Broadway, Los Angeles 54, Calif.

March 8-11 — Engineering meeting of the turbine in action, sponsored by Gas Turbine Division of ASME, Cincinnati, Ohio.

March 9-12—ASME Aviation Division Conference, Statler-Hilton Hotel, Los Angeles, Calif.

March 16-20—11th Western Metallurgical Exposition and Congress, American Society for Metals, Pan Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif.

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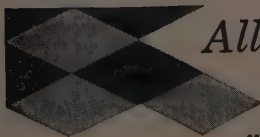
Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

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31-April 2—Polytechnic In- of Brooklyn's Ninth Interna- Symposium, subject: Milli- Waves, auditorium, Engineer- cieties Bldg., New York, N. Y., risors: Department of Defense rch Agencies and IRE.

31-April 3—National Aero- Meeting, Society of Automo- Engineers, Hotel Commodore, ork, N. Y.

5-10—1959 Nuclear Congress, ipal Auditorium, Cleveland, nformation: Engineers Joint il, 29 West 39th St., New 8, N. Y.

5-7—Second National Sympon Chemical & Petroleum In- entation, ISA, St. Louis, Mis-

7-10—1959 Welding Show and Annual Convention, American ng Society, International Am- atre and Hotel Sherman, Chi- ill.

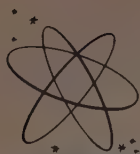
12-19—Air Force Assn's World ess of Flight, Las Vegas, Ne-

13-15—ASME Hydraulic Divi- onference, University of Mich- Ann Arbor, Mich.

18-22—Annual Meeting, Amer- Society of Tool Engineers, eder Hotel, Milwaukee, Wiscon-

22-24—1959 Annual Meeting, te of Environmental Engi- LaSalle Hotel, Chicago, Illi-

29-May 3—ASME Metals Engi- Division Conference, Shera- n-Eyck Hotel, Albany, N. Y.



J. H. DOUGLAS, AF Secretary: "Our deterrent power can certainly be kept strong . . . if we stay on our present course and make timely decisions to bring new weapons into production when their development and effectiveness [are] reasonably certain."



GEN. T. D. WHITE, Chief of Staff: "We must achieve . . . a strong posture which will deter the application of enemy power. . . . This requires strict application to the development of the three essentials of aero/space power — research, readiness, and reaction."



GEN. C. E. LeMAY, Vice Chief of Staff: "There can be no margin of error. . . . Our country has an enormous investment in its Air Force, and it is our job to provide the best product that this investment can buy. A bad product will jeopardize . . . the free world."

Where does AF go from here?

Top officials forecast trends for S/A

Technologically, flight just is no longer what it used to be even a few years back. How has this startling development affected the plans of the Air Force? Here is an exclusive and detailed report on USAF's new philosophy in the space age.

by **Robert M. Loebelson**, Associate Editor

ALTHOUGH President Eisenhower's budget for fiscal 1960 provides the Air Force with about the same percentage of Defense Department funds that it has been getting ever since the Korean War, USAF leaders recognize that a revolution has taken place in airpower. They are changing their plans accordingly.

The advent of missiles and the changes that have taken place in "conventional" aircraft have dictated a change in philosophy. The new emphasis on space is also an important factor.

To find out which way the Air Force will go in the 1960s, SPACE/AERONAUTICS interviewed top USAF leaders, studied official policy statements, sought background guidance from lower-ranking officers who do

Puts It on the Line . . .



LT. GEN. C. S. IRVINE, Deputy Chief of Staff, Materiel: "[The Air Force] does not have its own pool of scientific and engineering manpower, since it is convinced that it can obtain more efficient and . . . economical results by using skills already available in industry."



MAJ. GEN. B. A. SCHRIEVER, Commander, BMD: "We now have to make the same kind of basic, far-reaching, long term decisions—looking toward 1963 and beyond—as we made in 1954 [or] we shall not be able to [make use] of [what] we have already achieved."



D. C. SHARP, Assistant AF Secretary, Materiel: "We rely primarily on our contractors to provide their own facilities or to subcontract. Where this is not feasible, we try to use . . . idle plants . . . and as a last resort construct new facilities."

the spade work on policy changes, and analyzed current action to obtain clues for the future. These are its findings:

- *Missiles vs Aircraft* — Air Force officials have been trumpeting the line that "missiles will never completely replace aircraft" for so long that they have almost begun to believe it themselves. The old dictum that "missile will complement combat aircraft but will not supercede them" still applies—but not to the extent that the public-at-large has been led to believe.

Continued firings at Cape Canaveral—some wholly successful and some only partly so—over the past two years have convinced USAF that electronic devices can make more decisions than had originally been thought possible.

On some missions, a pilot will still be needed. But the feeling is growing in USAF that the degree of "missilization" will continue to rise.

One important area where missiles may some day in the 1960s completely replace manned aircraft is that of air defense. It is true that USAF is hedging its bet on the Boeing Bomarc area defense missile by sponsoring the development of the North American F-108 Mach 3 interceptor (which will launch a nuclear-tipped air-to-air missile). But one of the highest-ranking USAF officers concedes that the F-108 may be the last manned interceptor.

"We will have more complete missilization in the air defense field than anywhere else," he admits. "And the day may come where even interceptors of the F-108 type will not be able to handle the job. If that happens,

air defense missiles may be charged with the task of defending this country against aircraft or missile attacks."

Is the same thing true of weapon systems for the Strategic Air Command? The answer seems to be a limited "yes."

More than \$100 million per B-70

The Boeing B-52G (which will launch the North American Hound Dog air-to-surface missile) will phase out of production in 1961. A subsonic aircraft, it is admittedly not everything the USAF would like to have, even though it will be able to launch Hound Dogs and McDonnell Quail decoy missiles simultaneously. The supersonic B-58 also is to have a limited production run in store. Convair, which had planned to build 47 B-58s with fiscal 1959 funds, will produce only 36. Including orders from 1960 money, total B-58 production will be only about 106 units.

Still upcoming for SAC is the North American B-70 Mach 3 bomber. But this aircraft, it is reported, will cost more than \$100 million a copy in "mass" production. Obviously, USAF cannot afford to buy many B-70s if its total appropriation for weapon systems procurement continues to range around \$7 billion a year.

As one USAF official put it, "The B-70 may turn out to do everything we want. But we can buy a considerable number of Atlas or Titan or Minuteman

more on next page

ICBMs for the price of one B-70." The going price for an Atlas is around \$2 million—USAF will be able to procure 50 or more Atlas missiles for the price of one B-70.

As far as SAC is concerned, therefore, the final decisions on the types of weapon systems to be procured depends only in part on technical factors—economics may well dictate the choice. USAF may well end up with fewer bombers and more ICBMs in SAC in the 1960s.

According to a high USAF source, the B-70 will not be our last manned bomber—it will be followed by a nuclear bomber.

For tactical operations, the missile also seems to be pushing the aircraft out of the picture. The Army, which would like to control its own support of ground troops, has been claiming for several years that the fighter bombers used by the Tactical Air Command fly too high and too fast to do the foot soldier much good.

Missiles for support missions

USAF now has the Lockheed F-104 and the Republic F-105 in production for TAC. But USAF missiles like the Martin Matador and Mace and Army missiles like the Corporal, Sergeant, Redstone, and Pershing will take over more and more of the ground support job. The Air Force has neither a manned fighter bomber nor a manned light bomber under development to succeed the F-104, F-105, B-57, and B-66.

• *Nuclear Aircraft Propulsion*—Russian progress with nuclear-powered aircraft has intensified USAF interest in the field, even though top USAF echelons have never been able to get together on the need for such an aircraft. One high USAF official says, "The U.S. cannot afford to ignore the advantages of nuclear aircraft propulsion." But the Air Force is not the only U.S. agency concerned with airborne reactors. The program was cut back last year (from \$250 million to \$150 million annually) on the advice of Dr. James R. Killian, President Eisenhower's Special Assistant for Science and Technology. It seems destined to stay at that level unless Congress demands a speed up.

• *Airlift*—One of the highest officers in the Air Force says, "I don't think we're short of all reasonable airlift requirements." But the Army and many influential members of the House and Senate Armed Services Committees think otherwise. Net result: USAF next year will begin to replace and augment its airlift fleet of C-54s, C-118s, C121s, C-124s, C-130s, and C-133s.

What type of aircraft will the USAF procure for airlift purposes? Says one high official, "They'll be jet cargo liners based on existing commercial aircraft like the Boeing 707, Douglas DC-8, or Convair 880."

Does this rule out the turboprop? "Yes. If we're going to modernize the Military Air Transport Service, we might as well do it with the fastest planes available."

• *Air-Breathing vs Ballistic Missiles*—Is there a place in the Air Force for intercontinental air-breathing missiles (such as the Northrop Snark) once ballistic types are perfected? Replies one high official, "I can't see how jet-powered missiles would be considered for intercontinental bombing once we have ICBM's in quantity. But air-breathing missiles con-

ceivably can be used for reconnaissance purposes. Actually, though, ramjets make more sense for reconnaissance missiles than turbojets."

• *Aircraft in Inventory*—In the past, the Air Force has considered the operational life of first-line aircraft as about three years for fighters and five years for bombers. But the operational requirements of new airplanes have changed so much in recent years that they have become fantastically expensive. The upshot is that USAF can no longer have such a quick turnover.

Says one high official, "We can't afford to turn our first-line planes over that fast. Every new model will have to represent a great improvement over the plane it replaces. And even then, the new airplanes will not be ordered in anything like Korean War quantities."

USAF management and procurement personnel now recognize that the dollar sign will be the limiting factor on the number of planes to be procured each year. "With seven or eight billion a year to buy aircraft and missile hardware, we simply won't be able to afford many units of any weapon system. Obviously, the more than 20,000 aircraft in the Air Force's inventory will move downward each year from now on," reports one top official.

• *Space Activities*—Despite the fact that most of the nation's astronautic research is in the hands of either the National Aeronautics & Space Administration or the Pentagon's Advanced Research Projects Agency, top USAF officials are certain there will be many potential military applications. And they are equally certain that most of these applications will be an integral part of the Air Force's missions. As a result, USAF planners are scheduling many space research projects with R&D funds that will be voted for fiscal 1960 and future years.

Project Sentry, the AF-Lockheed WS-117L reconnaissance satellite, has been all but absorbed by ARPA's forthcoming Project Discoverer series of firings. But USAF has several other man-in-space programs under way, including the North American X-15 and the Martin and Boeing approaches to Project Dyna-Soar. Various other proposals to put man in space involve the use of Thor, Atlas, and Titan ballistic missiles for the first stage.

• *USAF and Industry*—High Air Force officials are unhappy about the prospect that some of the old-line aircraft firms may go out of business, but they claim they have very little choice. One explains it this way, "Several years ago, traditional Air Force suppliers were warned that they had to build a better mousetrap or else. Some of the companies took the warning, stepped up their own research work, and ended up in good shape. Others didn't do as well and they're suffering now."

"Much as we'd like to help, the number of dollars available is strictly limited. And that's why we won't be able to throw business toward some companies who have been filling Air Force requirements for years. We are fortunate in one sense, though. These companies are being replaced by others who had the foresight to buck for Air Force business."

Competition for the Air Force dollar is certain to get tighter in the 1960s as fewer weapon systems are planned. For some firms, the competition will be too strenuous and they will become either subcontractors to the few remaining major primes or go out of the aviation business completely.—End

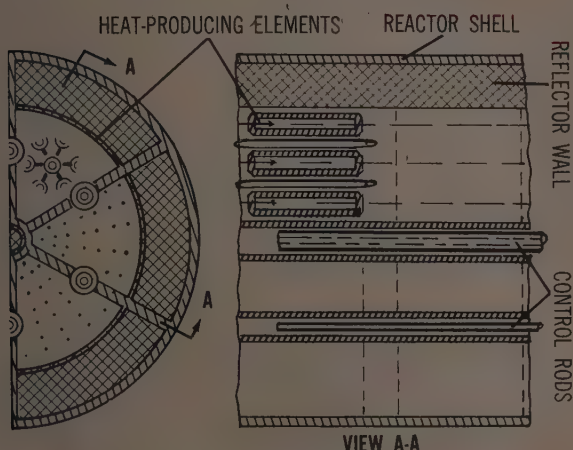
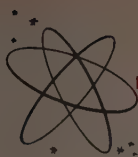


FIGURE 1: Homogeneous uranium-beryllium reactor that heats a gaseous intermediate heat transfer agent.

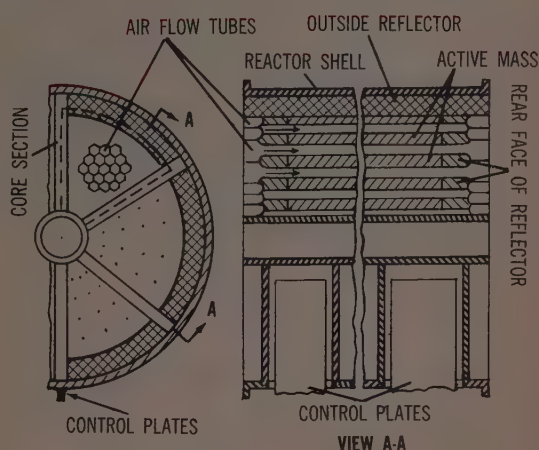


FIGURE 2: Homogeneous uranium-beryllium reactor for direct heating of air flow through the engine.

Airborne fission reactor

controlled through neutron absorption

This is the second article of a series based on a detailed, authoritative Soviet report on the development of nuclear aircraft engines. The first article in this series appeared last month (p. 132); the next article will appear in April.

by G. N. Nesterenko, A. I. Sobolev
and Yu. N. Sushkov*

A NUCLEAR REACTOR is controlled by changes in its reactivity. Basically, what you do is control the number of neutrons "floating" around in the reactor's core.

Such control can be achieved in many ways—by varying the amount of nuclear fuel in the core, the arrangement of reactor components, the amount of moderators, the effective area or thickness of the reflectors, or the positions of external neutron sources relative to the core.

*Condensed from "Primeneniye Atomnykh Dvigatelyey v Aviatsii" (Application of Atomic Engines in Aviation), Military Press of USSR Defense Ministry, Moscow '57, a partial translation of which is available as "PB 131908T" at \$3 from Dept. of Commerce, Office of Technical Services, Washington 25, D. C.

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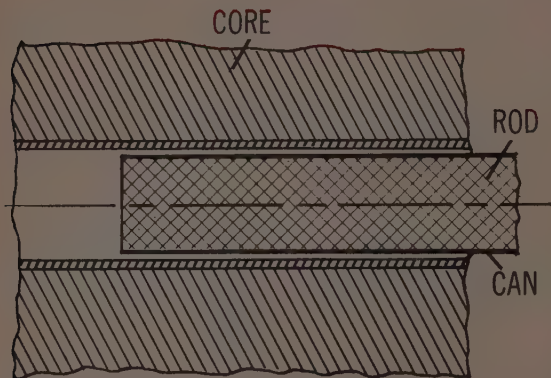


FIGURE 3: Control rod for a fast neutron reactor.

For the designer, the simplest and most effective control method—particularly in the case of reactors using thermal neutrons—is to regulate the secondary neutron flux. For this kind of control, you need materials that are good neutron absorbers.

Cadmium is the most neutron-absorptive material, but its rather low melting point of about 321 deg C restricts its use. Boron, boron carbide, and boron steel are the materials used most commonly. Boron is highly absorptive, has a high melting point, and has the further advantage of remaining virtually free of radioactivity.

Controls must allow for all fuel

The initial charge of nuclear fuel in any reactor exceeds the minimum critical weight. Some of the excess is a reserve against consumption. However, the greater part of it, the so-called reserve against poisoning and temperature effect, normally does not take part in the reaction. However, the reactor control system must be designed to allow for all the fuel present.

Usually, the control system consists of movable, neutron-absorbing rods inserted into the reactor core. The compensating capacity of these rods, which must exceed the initial reserve reactivity, depends not only on the material used but also on their diameter and position in the core.

In modern nuclear reactors, the assigned power setting is automatically maintained within 0.1 per cent. Any deviation in power produces a change in the neutron flux, which is immediately recorded by ionization counters mounted around the core. The output of the counters is then fed into the control system as a servo loop error signal to change the position of the rods.

For changes from a steady state of operation to another of greater power, the rod is withdrawn from the core. In this way, the absorption of secondary neutrons is decreased and the reactivity increased. Once the desired power level is reached, the rod must be returned to a position corresponding to zero reactivity.

To reduce power, the rods must be inserted deep into the core. After the desired power level has been reached, they are then returned to their initial position.

If the shift to new power levels is completed very quickly and there is no significant change in core temperature, the rods will be returned almost to their initial position. How far the rods are displaced determines the degree of reactivity (i.e., the time rate of change in power).

Reactivity tends to fall off

Enough nuclear fuel is consumed during operation for the reactor reactivity to have a neutral tendency to fall off. To prevent a spontaneous shutdown, it is necessary to provide for constant refueling or reduce neutron loss during operation.

The accumulation of reactor fission products that are strong neutron absorbers also reduces reactivity. This loss again must be offset to keep the reactor going.

Core temperature variations—which lower if they are upward—also introduced spontaneous changes that must be corrected. In all cases, the control system must automatically compensate for these normal dynamic changes in reactivity to maintain the assigned power settings.

Emergency protective rods are also needed that can stop the nuclear fission reaction, for conditions may arise in which even the briefest delays in shutdown will prove disastrous. Typical danger signals include:

- an excessively fast rise in temperature during startup,
- a rise in core temperature above "safe" levels,
- a drop in the pressure of the heat-transfer agent (indicating leak in the system or pump failure).

In an aircraft reactor, the emergency rods must be designed for operation under all possible attitude and acceleration conditions (independently of the normal control rod system). The simplest, lightest, and most reliable drives are spring-actuated or pneumatically driven by a gas or powder charge.

For safe operation, the rate of change in reactivity during startup or power increases must be less than about 0.005-0.006. Under these conditions, a thermal-neutron reactor (Fig. 1) will take about six seconds to increase its power 2.7 times and about 30 seconds to increase to 500 times. A fast-neutron reactor (Fig. 2) increases its power at about the same rate.

Generally, a fast-neutron reactor is more dangerous than a thermal-neutron reactor. If, for any reason, the reactivity reaches a value of 0.00755, the fission reaction will proceed at such a speed as to outpace all existing systems of emergency protection. Therefore the initial reserve of reactivity in a fast neutron aircraft reactor must be kept very small.

Fuel reserve doesn't affect life

There isn't much of a problem here, for only a small reserve is needed to compensate for poisoning and temperature effects. Also, the life of an airborne reactor is limited not by the fuel reserve but by the reliable operation of the shells of the heat-producing elements.

To keep a 300,000-kw fast-neutron reactor operating for 500 hours, the initial reactivity reserve need only be 0.012. More than half of the entire reactivity reserve must be engaged in the reaction, i.e., all control rods must be pulled out half way before fission takes place.

The main problem with control systems for a fast reactor lies in the design of the control devices. Any material strong enough to withstand the design loads invariably is a poor absorbent for fast neutrons.

One way to get around this difficulty is to vary the position of a certain portion of the nuclear fuel relative to the core. The control devices now can take the form of rods of nuclear fuel that are enclosed in protective metal cans and have their own, independent cooling system. The only trouble is that the large amounts of heat that must be dissipated from the control devices complicates the design considerably.

Beryllium rod is most efficient

On the other hand, the low compensating capacity demands of a fast reactor simplify the basic problem. *Figure 3* shows a control device that is a rod made of

a good retarding agent such as graphite or beryllium. The rod is housed in a can consisting of a material that is a good absorber of slowed neutrons.

When the rod is withdrawn, the fast neutrons pass through the thin walls of the can and participate in the fission reaction. When it is inserted in the core, a portion of the neutrons passing through are decelerated and absorbed by the material of the can. (The can may form a part of the channel wall rather than of the rod itself.)

The smallest diameter per unit compensating capacity is provided by a beryllium rod. Boron or boron carbide may also be used. With these materials, the control rods of a fast neutron reactor differ from those of a thermal neutron reactor only in having a somewhat greater diameter. Cans are not necessary, since the boron, being a good moderator, is also a good absorbent for delayed neutrons.—End

Design Data for Uranium-Beryllium Reactor Core

The core shown in *Figure 2* directly heats the air flow through the engine. It contains an active mass of uranium beryllium alloy housed in a hermetically sealed cavity that is penetrated by a large number of thin-walled air flow tubes. (The active mass occupies the space between the tubes.)

The ends of the tubes are welded to form hermetic seals at the front and rear surfaces of the reactor. To simplify production and assembly, the core is made up of several sections.

A solid outside reflector made of beryllium is used to reduce neutron leakage. As it is not a continuous-end design, there are layers of pure beryllium between the tubes at the reactor's front and rear surfaces to reduce neutron leakage through the end areas. The control devices, placed between the sections of the core, are displaced along the radius of the reactor cylinder so as not to crowd the inlet and outlet areas.

This reactor is designed to deliver 32,000 kg (70,400 lb) top static thrust at sea level. Its maxi-

mum thermal capacity is 300,000 kw, which corresponds to a release of 258×10^9 cal/hr. The top temperature of the heating surface of the core is 1100 deg C; that of the air flow through the engine, 950 deg C.

The cylindrical core is 1.9 m (6.24 ft) in diameter and in length. The beryllium side reflector is 15 cm (5.91 in.) thick. The thickness of the layers of pure beryllium at the front and rear surfaces is 10 cm (3.94 in.).

There are 17,000 air flow tubes, each with an ID of one centimeter (0.39 in.). They are made of a heat-resistant nickel alloy.

The initial uranium 235 charge is 70 kg (154 lb). The combustion reserve, which ensures continuous operation at full capacity for 500 hours, is 6.5 kg (14.3 lb).

The weight of the beryllium—which is alloyed with uranium—is about 2000 kg (4400 lb). The combined weight of reactor and reflector is 9500 kg (20,900 lb).



How feasible are Mars and Venus probes?

The next step in space flight beyond the current moon shots clearly are unmanned probes that will reach Mars and Venus, the planets nearest to us. This article reports on the design problems such vehicles will pose and on the results we can expect from successful early interplanetary probes.

by Englebert Kirchner, Managing Editor

UNMANNED FLIGHTS to our nearest planets will be a logical extension of our present attempts to reach the moon—which, after all, can be considered to be a planet orbiting about the earth. As no radical innovations, therefore, will be needed for true interplanetary probes, we can say confidently that Mars and Venus probes should become possible before too long. What's more, once we have succeeded in launching such vehicles, shooting small payloads of 100 lb or so to such farther planets as Jupiter will require but another logical extension of the art.

Right now, of course, all that we can hope to do is to reach Mars and Venus, the nearest planets, along the most economical flight paths. Such launchings are the only ones for which tentative official plans have been announced so far.

Interestingly enough, both Mars and Venus are in favorable positions for probe launchings during the first 10 months of this year. During this period, an unmanned, instrumented payload that leaves the earth at about 40,000 fps on a one-way trip, follows a partly elliptical flight path, and suffers no unexpected perturbations (from near passes of asteroids, for instance) would reach Venus in 150 days and Mars in 250 days.

Actual impacts will not be necessary for the success of the first interplanetary probes. A payload that sends back data from "deep" space and from the vicinity of Mars or Venus will suffice to bring us much closer to answering the questions that provide the scientific reason for penetrating interplanetary space. These questions are:

- How much *hydrogen* is there in space? Astrophysicists believe that space is permeated with widely diffused and partly dissociated hydrogen. The vacuum instrumentation of an interplanetary probe could measure the concentration of this gas.

- What *other gases* are present in space? There may be small traces of helium and other gases. A probe's mass spectrometers, ion gages, etc., should be able to detect these traces.

- How much "*hard*" *matter* is there in space? We know there are meteors and dust particles in the space around the earth, but we don't know how this matter is distributed—whether, for instance, it occurs in clouds or not. (Attempts to answer this question with the microphones and impact-sensitive elements of our first satellites were not very successful, partly because of the crafts' low altitudes.)

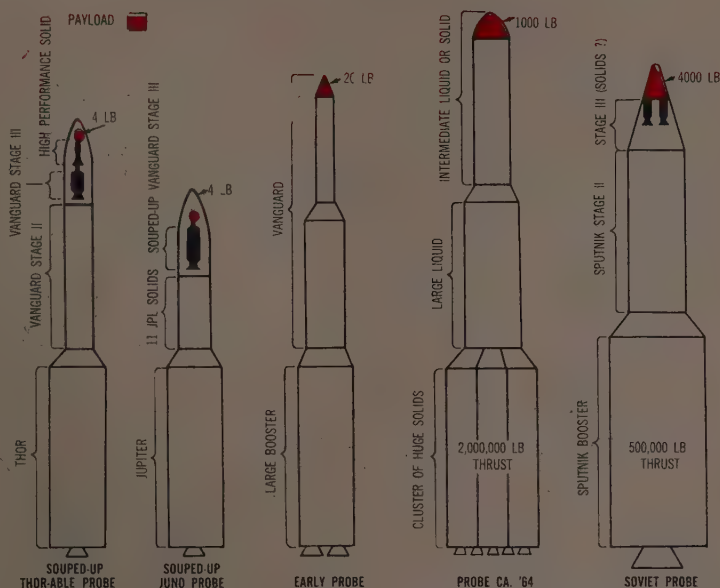
- What *magnetic and electric fields* exist in space? Astrophysicists know there are such fields, but a probe outside the earth's own magnetic field is needed to find out more about them. Such information would also give us some clue to the interaction between the sun's corpuscular and electromagnetic radiations and the diffused hydrogen in space.

- What are the *gravitational potentials* in space? The flight path of an interplanetary probe—which could be tracked quite accurately—would give us some idea of the gravitational forces acting on it, enabling us to estimate the gravitational potentials in space. These estimates probably would be more accurate than our present ones, which are based on measurements of the flight paths of comets, asteroids, the moon, and the nearer planets.

- What are *Mars, Venus, and their atmospheres* like physically? A probe in the immediate vicinity of Mars or Venus could pick up information about the upper regions of the planet's atmosphere by means of mass spectrometers and other instrumentation. With infrared detectors and video cameras, it might even get a good reading of the planet's surface.

Of course, even more data on our near planets could be gathered by payloads that actually hit Mars or Venus or skim through their atmospheres. This, however, is still a theoretical consideration—even supposing an interplanetary probe had a reasonable chance of hitting its target (which it won't have for

SOME POSSIBLE configurations, based on unclassified data, of vehicles with one-way, non-impacting Mars or Venus payloads. Payload of "1964 probe" includes an ion rocket; third-stage rockets of Soviet probe weigh about 2000 lb. All payload weights are approximate.



quite a while), there remains the terrific problem of getting data back from an impacting payload.

Indeed, we'll have to strain our technical resources to the limit just to reach the vicinity of Mars or Venus. As our moon shots to date have shown, even highly refined propulsion and guidance and control systems for large rocket vehicles achieve deep-space capability only after much development and testing. In the immediate future, interplanetary launching vehicles will be operating so close to their limits that the slightest performance loss will lead to failure.

The launching vehicles naturally must have high mass ratios. Quite a headache in themselves, these will then lead to structural problems. Furthermore, improvements in ground handling and servicing will be needed—the probes will have to be launched within minutes of the ideal moment when the target planets are in the proper position for the most economical flight path.

The guidance and control problems of an interplanetary probe will be worse than those of an ICBM. For one thing, the launch path will be more nearly vertical; for another, more accurate pitch and yaw control will be needed.

Ion engine likely for payload

Once the actual payload has separated from the launch vehicle, it may have to be attitude-stabilized. If corrective thrust is needed to keep it on its programmed flight path, it will have to carry its own propulsion system. The same, of course, will hold if the payload is to return to the earth.

If the payload is to have its own powerplant, this

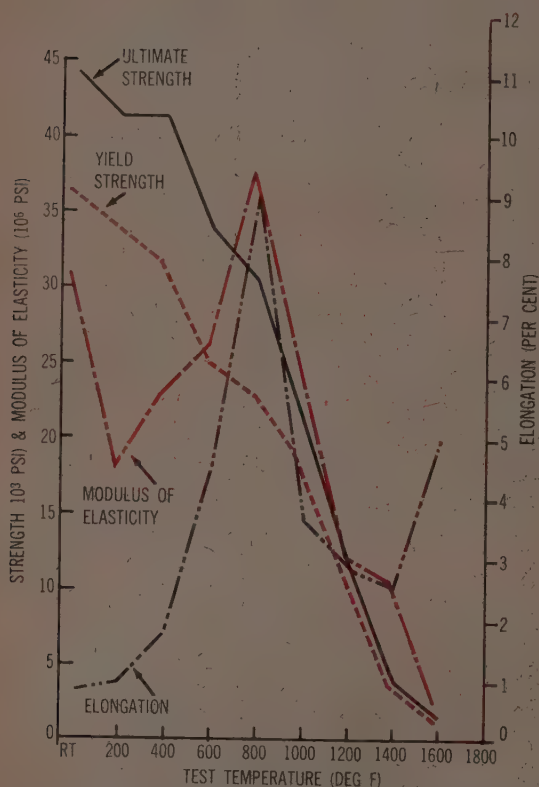
is much more likely to be an electric, or ion, device than a chemical one—an ion engine would weigh less than the many hundreds of pounds of a chemical system consisting, say, of small rockets burning 90 per cent hydrogen peroxide as a monopropellant.

Unfortunately, it will be some time before a suitable ion rocket—which would weigh less than 100 lb—is developed. Such a rocket should produce a thrust of at least 5-10 lb.

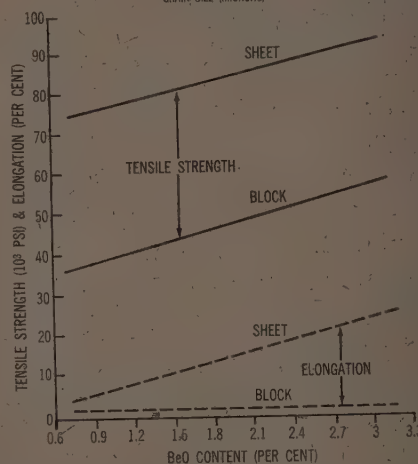
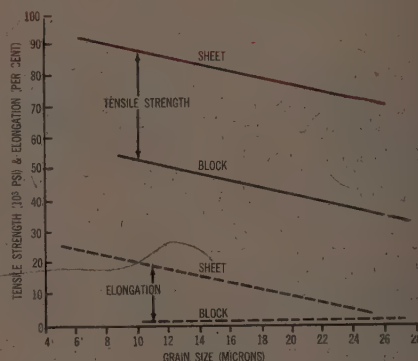
It would, of course, be an absolute necessity if propulsion of long duration—say, a month or so—were needed for the payload. The ion engine of an interplanetary probe would draw its power from a nuclear or maybe even a solar source.

The same type of power source would be used for the probe's instrumentation. Even if intermittently operating electric circuitry extended their life over several months, batteries should prove hardly worth while, and it seems safe to assume that, by the time we've managed to build the other devices needed for an interplanetary probe, we'll also have a small nuclear or solar power source that will last indefinitely.

The main problem in tracking an interplanetary probe will be that this body subtends only a very small point, or target, in space. If "balloon" antennas or inflatable reflecting surfaces could be included in the payload, this would improve target identification. In any case, though, it should be possible to track the payload all the way to Mars or Venus—the necessary equipment would be several large radio telescopes of current design, which would be stationed at points on the earth, and, in the probe, a radar beacon weighing about 5-10 lb and Minitrack or similar transmitting equipment with an output of five watts or so.—End



TENSILE MECHANICAL properties of Brush QMV beryllium (left) in tests of limited samples at Lockheed Missile Div. Right: Grain size and beryllium oxide content



vs mechanical properties of beryllium in Brush tests. Blocks were vacuum-hot-pressed; 0.06-in. sheet was hot-rolled.

State of the art: Beryllium

- Ductility problems have been exaggerated
- Weldability and formability better than expected
- Reinforced Be skins foreseen for structural use

by Irwin Stambler, Associate Editor

WORK ON BERYLLIUM is still in its early stages. Nevertheless a great body of data on properties and fabrication has become available, much of it over the past few months.* This information often is based on limited samples, but it does give promise that many of the hopes pinned on this metal will not be disappointed.

* Of particular interest is "Beryllium for Structural Application: A Review of the Unclassified Literature," recently published by Battelle Memorial Institute, Defense Metals Information Center, 505 King Ave., Columbus 1, Ohio.

Ductility, probably beryllium's most serious handicap, is getting a lot of attention. The WADC alloying program, under the direction of The Brush Beryllium Co., 4301 Perkins Ave., Cleveland, Ohio, is showing some progress. Brush researchers told SPACE/AERONAUTICS that the program actually has provided more information on improving high temperature strength and ductility than on room temperature ductility. (Beryllium's high temperature ductility is variable, giving elongations of 20-30 per cent at 800-1000 deg F as against only 1-3 per cent at room temperature and above 1500 deg F).

The aims of the program, the researchers state, include alloying as well as attempts to make composites in which the beryllium matrix is surrounded by other materials. The main line of attack has been to promote grain boundary slip. Even with as brittle a material as BeO, it's claimed, this has already provided worth-while results.

So far, the addition of about 3-4 per cent of beryllium oxide by weight seems to be one of the best ways of combining optimum high temperature strength with good room and high temperature elongation. The BeO-Be product is somewhat similar to sintered aluminum powder.

One problem is that the amount of BeO seems to be critical. Too little doesn't give the desired improvement, and too much makes the material brittle again.

As far as alloying elements are concerned, either solid-solution elements (such as copper, silver, nickel, or gold) or elements that are immiscible or form intermetallics (such as aluminum, magnesium, zinc, cadmium, or lithium) can be used. The latter approach looks better at the moment, researchers state. However, the principle means of controlling the properties of beryllium is control of grain size or orientation, in the opinion of Brush scientists.

Current research work has had as one objective the development of a heat-treatable alloy that will show

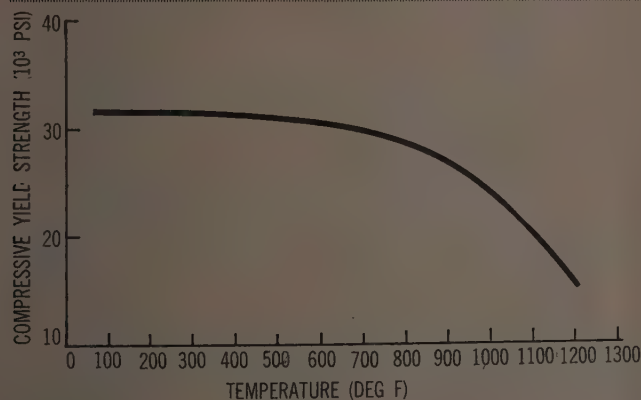
100,000 psi tensile strength in sheet. Brush reports, though, that in one experimental alloy values as high as 150,000 psi have been obtained. This strength was achieved not so much through alloying as through certain methods of working the material. It would seem to represent a significant breakthrough—in the past, 100,000 psi was thought to be a limiting factor.

As this shows, the study of grain size, crystal direction, etc., might prove more fruitful than alloying for improving beryllium's properties. With fine grain in and considerable cold work, an extruded bar was obtained in one case that had a tensile strength of 140,000 psi at room temperature.

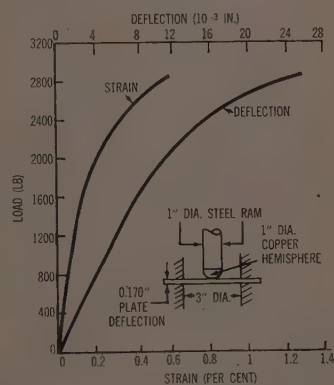
Anisotropic structure is studied

Some of this work is being done on the randomization of anisotropic structure. For some samples, a "pseudo" elongation in all directions of 3-5 per cent at room temperature can be obtained. Whether this is true ductility or not, researchers say, it certainly is plastic deformation.

Brush engineers emphasize that the ductility trouble isn't as rough as it's sometimes made out to be. Part of the problem lies in our lack of experience in proper application of the material. Beryllium isn't glass- or ceramic-brittle, these engineers note. In fact, it's less brittle than many types of grey iron casting, SPACE/AERONAUTICS was told. Sheets or parts of beryllium have been dropped on hard surfaces without breaking. By such means as properly orienting the slip planes, 3-30 per cent elongation at room temperature has been obtained, with minimum guaranteed elongations of three per cent available. These values make it possible to fabricate cylinders, truncated cones, etc. Some test specimens have shown 5-15 per cent room temperature elongation.



COMPRESSIVE YIELD of hot-pressed beryllium (left) at 0.2 per cent offset in North American tests. Right: Unusually good ductility for beryllium under biaxial



stress at 6:1 reduction rate was shown in Martin tests of cold-compacted plate upset at 1850 deg F. Measurements were made at bottom center.

Rolling Temperature vs Tensile Properties of Bidirectionally Hot-Rolled Beryllium (QMV LYB-1043)

Rolling Temperature (deg F)	Processing & Test Direction	Ultimate Tensile Strength (psi)	Yield Strength (psi)	Elongation in 2 In. (per cent)	Width Reduction in 0.5 In. (per cent)	Average Grain "Diameter" (microns)*	Surface Hardness (R _B)	Basal Plane Orientation (deg)
1300	as rolled longitudinal	91,000	65,000	13	13	22	101	9.1
	transverse	85,000	70,000	5	3.9			
	annealed longitudinal	82,000	64,000	5	3	25	100	8
	transverse	86,000	63,000	8	7			
1400	as rolled longitudinal	80,000	57,000	13	11	28	101	7.3
	transverse	84,000	60,000	12	10.5			
	annealed longitudinal	80,000	58,000	15	14	65	95	6.5
	transverse	83,000	58,000	13	13			
1475	as rolled longitudinal	70,000	59,000	2	2	80	96	5
	transverse	85,000	61,000	18	14			
	annealed longitudinal	75,000	60,000	2.5	2.5	95	95	9.1
	transverse	85,000	61,000	18.0	14			
1550	as rolled longitudinal	63,000	57,000	1	1	94	94	9.1
	transverse	65,000	53,000	1.5	1.2			
	annealed longitudinal	64,000	55,000	1.5	1.2	95	95	9.1
	transverse	64,000	53,000	1.5	1.2			
1650	as rolled longitudinal	61,000	51,000	1.1	1	95	95	9.1
	transverse	61,000	53,000	1.2	1.2			
	annealed longitudinal	60,000	50,000	1.5	1	95	95	9.1
	transverse	63,000	51,000	1.5	1.2			

* Grain shape factor 5:1.

Many other beryllium "taboos" have been exploded, too. The metal once was thought to be unweldable as well as hard to form. Now sample sheets have been wrapped around mandrels to form such shapes as cones and then welded in studies at Brush. Sheets have been successfully flash- and butt-welded to 20 mils.

Fusion welding with beryllium filler metal looks particularly promising. It's done with a tungsten arc under inert gas. To minimize thermal shock, the metal that is to be joined must be heated to 1000 deg F or over. Because of Beryllium's notch sensitivity, complete penetration during welding with no discontinuities is needed for a good weld.

In other development programs, beryllium has been successfully soft-soldered, furnace-brazed and bonded with such agents as epoxies. Brush has also developed solders with 5000, 7000, and 12,000 psi shear strengths.²

Still other programs are aimed at the use of beryllium

for honeycomb sandwich construction and wire. Experimental beryllium foil in strip form is in the works. The goal is to obtain 100-ft lengths. So far the program has reached 14 ft.

Those working in this area feel it would be relatively easy to devise forming methods for beryllium core or even just corrugations. The latter might be advantageous, researchers note—because of the metal's rigidity, corrugations could provide as good a structure as a cell shape. Present work on wire is based on a filament-wound composite structure.

Beryllium has already been applied in production quantities in inertial guidance gyros, accelerometers, and computers. These applications call for a frame material that's stiff, dimensionally stable, and light enough for miniaturization that does not require sacrifices in accuracy.

Another major use of beryllium now under study is

the replacement of steel parts in aircraft brakes. The steel is used in high performance designs to absorb the heat generated at today's high takeoff and landing speeds. However, steel has a specific heat at room temperature of about 18 btu, as against 0.42 for beryllium. (Copper has roughly the same specific heat as beryllium but of course is much heavier.) Studies show that beryllium in brake applications could cut weight by as much as 75 per cent without any loss in heat absorption.

For such parts, the present thinking is to braze two pieces of steel onto a beryllium center. The reason for this is that beryllium's wear properties are still unknown. (Many researchers, though, believe the metal's wear resistance would be adequate.)

Beryllium, of course, is receiving a lot of attention as a heat sink material for missiles and spacecraft and as a skin material for high performance craft where strength is a secondary and rigidity at high temperature and high melting point are primary considerations. One design idea is to combine thin beryllium skin sections with reinforcing Z-sections of such materials as Inconel to get both rigidity and good high temperature strength.

Researchers caution that designers must allow for beryllium's notch sensitivity. For threaded members, for instance, a generous fillet should be used instead of a sharp thread. (In one instance, an outer steel rim was shrunk-fit onto a beryllium center disk.)

The two other major problem areas of beryllium are, of course, toxicity and cost. As far as the former is concerned, there is no danger until the beryllium dust and fumes exceed a certain percentage, scientists report. Solid beryllium can be handled quite safely; the only hazard arises when fumes or vapors result from some production process. However, as long as proper procedures are followed, all experts seem to agree, these

also present no problem. (The Air Force is preparing a User Manual on the safe handling of beryllium in all uses.)

Brush Beryllium reports no difficulty in delivering sizable quantities of fabricated beryllium within a matter of weeks. In rough form, today's hot-pressed block sells for about \$60-\$80 a pound. However, if beryllium production rises to the level estimated for 1961, this price may drop by perhaps as much as 30-50 per cent. This would mean contractors could get sheet for about \$50-80 per pound.

Present indications are that there is an ample supply of beryl ore. Also, large low grade deposits are being studied for possible exploitation by improved extraction processes.

Guaranteed minimums have been set

Brush is supplying sheet with guaranteed properties of 70,000 psi tensile ultimate, 55,000 psi tensile yield, and minimum three per cent elongation in the plane of the sheet in both directions. Development work gives hope that these values will be raised to 77-80,000 psi, 60,000 psi, and 5-15 per cent, respectively. Sheet is being supplied in sizes up to 20x40 in. in standard thicknesses from 0.02 to 1/4 in.

A great deal of work is also being done on BeO. As is generally known this alloy looks promising for such items as high temperature rocket nozzles. Another interesting test application is a sprayed-on electric insulation for electronic gear. In this case, BeO is electrically insulating but thermally conductive. Adding a certain percentage of BeO to fiberglass has provided an increase in that material's modulus from 10 to 20 million.—End

Tensile Creep Properties of Vacuum-Hot-Pressed Beryllium Block (QMV)*

Stress (psi)	Minimum Creep Rate (per cent/hr)
At 800 Deg F	
8,290	0.00028
10,090	0.00056
12,490	0.0048
15,000	0.052
18,000	0.142
At 1000 Deg F	
4,190	0.001
4,930	0.01
5,290	0.05
At 1250 Deg F	
2,000	0.0009
2,220	0.018
2,700	0.07
3,190	0.28
At 1350 Deg F	
650	0.00036
970	0.0072
1,090	0.051
1,390	0.3

* Materials Advisory Board data.

Formability of Beryllium Sheet:

180-Deg Bend Tests on Sheet 1/16-In. Thick across Rolling Direction¹

	Temperature (deg F)	Min. Radius	Longitudinal	Transverse
Hot-rolled at 1650 deg F (30:1 area reduction, with some cross-rolling; approx. 1/2 in. wide) ²	700	4T		
	800	4T		
	900	4T		
	1000	2T		
	1100	2T		
Warm-rolled at 1200-1450 deg F (hot-rolled at 30:1 reduction and cross-warm-rolled 30 per cent) ³	1200	2T		
	800	—	8T	
	900	—	4T	
	1000	8T	2T	
	1100	2T	2T	
	1200	2T	2T	

(1) Materials Advisory Board Data. (2) In thicknesses from 1/16 to 1/8 in., can be deep-drawn with generous radii (10T) and low speed of deformation at 1000-1200 deg F; can be sheared and punched at 800 deg F if tools are at same temperature and shearing rate is low; can be riveted cold with aluminum rivets. (3) In thicknesses of 1/16 in. and lighter, can be deep-drawn at 1000-1200 deg F and sheared and punched at 800 deg F with tools at same temperature as metal; can also be cold-riveted.



"Gun barrel" launching

save ICBMs' first stages

Startling improvements in missile and spacecraft weight and range would become possible, the authors argue, if their novel proposal is taken up: to launch missiles and spacecraft under external power out of tunnels sunk deep into the earth.

by V. M. Tyler, E. C. Jackson and
R. M. Pierce

Head, R&D Mechanical Design Group, Missile Test Section
and Senior Engineer, Hughes Aircraft Co., & Assistant
to Vice President, Grand Central Rocket, Inc.*

UP TO 30 per cent of a current ICBM's takeoff weight may be needed for getting the missile off the ground and into an accelerated flight path out of the earth's atmosphere. With "gun barrel" launching, this basically parasitic weight could be converted into payload or traded for greater range.

Instead of taking off under its own power, the missile would be fired, or propelled, by pressurized gases from the "breach" of a vertical tube bored into earth to a depth of several thousand feet. This may sound fantastic, but preliminary studies for a mountain-top installation show the scheme is quite feasible.

Here is how the missile would be launched:

(1) The vertical tunnel, or shaft, ahead of the missile is evacuated just before launch. This reduces the aerodynamic effects on the missile during its accelerated flight through the tunnel.

(2) A series of explosive charges or gas generators,

strung out along the tunnel, is sequentially fired to build up and maintain an increasing pressure behind the missile. Enough force is generated to propel the missile into the atmosphere at an initial speed greater than that imparted by a conventional first stage engine with boost assist.

Calculations show that a missile of V-2 size and weight could be propelled to an altitude of over 1000 miles (without subjecting the structure to excessive loads). For a ballistic vehicle, the length of the tunnel might vary anywhere from 5000 to 20,000 ft. depending on the size, weight, and range (Fig. 2).

The problems of drilling a vertical shaft several thousand feet long out of perhaps solid granite are quite formidable. However, a unique self-propelled boring system has been devised (Fig. 1) that can be used to build vertical tunnels to any desired length.

Excavation starts at the lowest level of the vertical tunnel. First, a horizontal access tunnel is built to reach the site of the vertical tunnel. There an opening is cleared in which the boring is erected.

Holes for small dynamite charges are then bored in the overhead. Charges are set, the drillers retreat through a center tube to a safe area, and a detonation circuit energized.

Small chunks of rock loosened by the explosion pass through screening over an exposed drilling platform to a collection cone. From there they pass through the center tube to the top bucket of an elevator car. This car descends to where the pieces of rock are transferred to and removed in standard mine cars.

Through a reduction gear drive, an electric motor rotates the lower section (an inverted bucket) of the elevator car to raise or lower the entire unit. The bucket rides on pneumatic wheels set in a helix arrangement to follow a helical track fastened to the tunnel walls.

The drilling car, designed along the same lines, has its own prime mover and lower bucket "drive". A

*Hughes Aircraft Co., P.O. Box 5555, Tucson, Ariz. Mr. Pierce formerly was head of the Systems Analysis Section at Hughes' Launchers and Power Plants Dept. The authors wish to acknowledge the contribution of the late Hughes mathematician Paul Burke.

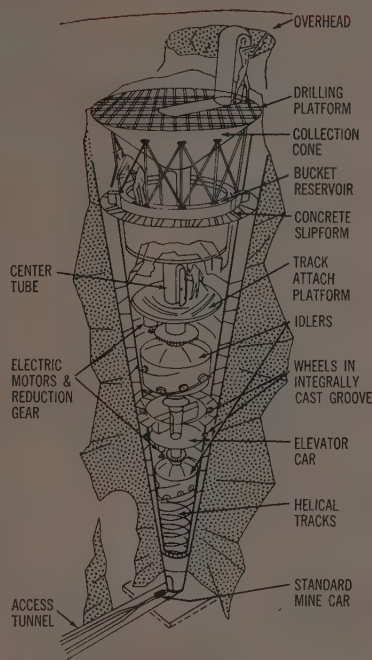
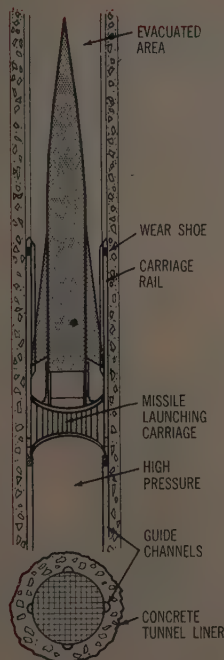


FIGURE 1: Design details (left) of missile carriage and other launching provisions of tunnel setup proposed to add to range and/or payload. Right: Tunnel drilling operation as it approaches the

surface after starting at the bottom of the shaft, where a horizontal access tunnel joins the vertical tunnel. (View is from above, hence the distortion of the constant-diameter tunnel.)

concrete slip form around the edge of the bucket is used for pouring new sections of the tunnel lining.

This bucket is charged with dry sand, a mixture of crushed rock and cement, and water stored in a separate compartment. The material is carried up from the lower level access tunnel by the elevator car and is delivered to the drill car through a pneumatic tube.

As the drilling car advances upward, new sections of helical sheet metal track are attached to the wall. When the tunnel lining is completed, the helical track is removed since it obviously would interfere with the close tolerance fit of the missile launching sabot.

Launching tracks in the concrete

Launching tracks molded into the concrete casing are lined with stainless steel sections along the entire length of the firing shaft. Tubular rails attached to the carriage ride in these tracks.

The missile carriage is a honeycomb construction—light yet rugged enough to withstand compressive loading. Replaceable wear shoes at each end of the tubular rails act as heat sinks and rail guides. Since there is little missile side loading, little friction, or heat, should be generated.

The bottom of the missile is nested in a fixture attached to the sabot platform. The propulsive force is

evenly distributed over the underside of the sabot to prevent cocking. Fin guides may be added to the tubular rails to keep the missile stable vertically and in roll.

As noted, the area in front of the missile is evacuated just before launching—by any of several rather simple methods. One fairly direct way would be to use available compressors, which have a capacity of 1,250,000 cu ft/hr. The first rocket motor or gas generator at the base of the tunnel is then ignited to build up the pressure behind the launching sabot and start the missile on its way.

A tremendous force can be generated, since the area in front of the missile is partly evacuated. In a 12-ft-diameter tube, a pressure differential of only 61.3 psi would produce a force of 1,000,000 lb. For even more thrust, water could be injected into the jet blast to produce flash steam. Upon condensing, the water would fall to the bottom of the shaft and could be reclaimed and stored.

Once the missile is on its way up the tunnel, pressure-sensitive switches ignite subsequent gas generators to keep the sabot moving. The gas pressures from these ports add up to the effective constant tunnel pressure behind the missile.

There is some air at the top of the tunnel, and the

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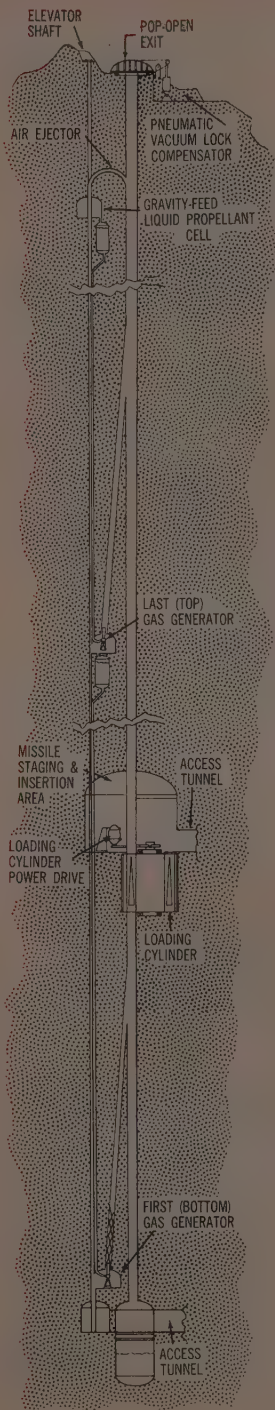


FIGURE 2: Vertical tunnels for missile and spacecraft launch would vary in depth from 5000 to 20,000 ft for ICBMs and spacecraft but could be simply sunk into small hills for area defense missiles.

moving missile carriage will tend to compress it. An ejector near the exit sucks in this "compressed" air, delivers it to an elevator shaft cut parallel to the missile launching tunnel, and discharges it into the tunnel below the missile sabot.

Another way of evacuating the tunnel before launch would be to set off an explosion to create a pressure wave above the missile. This would start an outward movement of air that would tend to drag along other air with it and produce a partial vacuum.

Still another way of getting the vacuum would be to operate a rocket motor or gas generator at the upper end, or exit, of the tunnel as an ejector. The exhaust would create a venturi effect and draw air out of the tunnel for direct discharge into the atmosphere.

This system has the advantage that the missile leaving the tunnel is surrounded by high speed gases traveling in the missile's direction. These gases would also ease any possible shock as the missile passes from the partially evacuated environment of the tunnel into the static pressure of the ambient atmosphere.

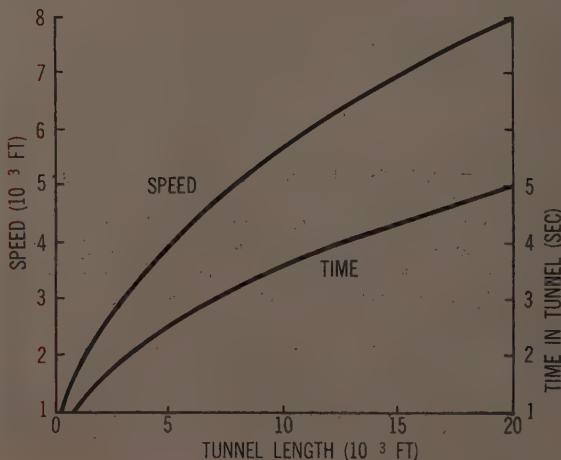
Some of the advantages of tunnel launching are not too obvious. For example, an abort during first-stage of flight does—i.e., in the tunnel—not mean the loss of a multi-million dollar missile. In such cases, the missile simply settles back on its gas cushion and slowly returns to the launching level.

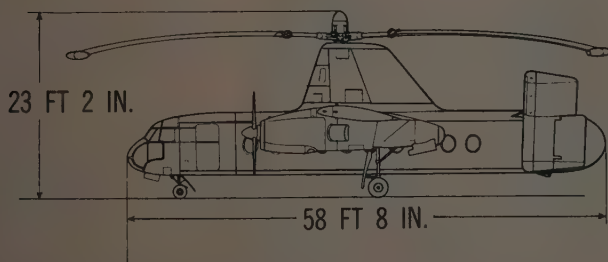
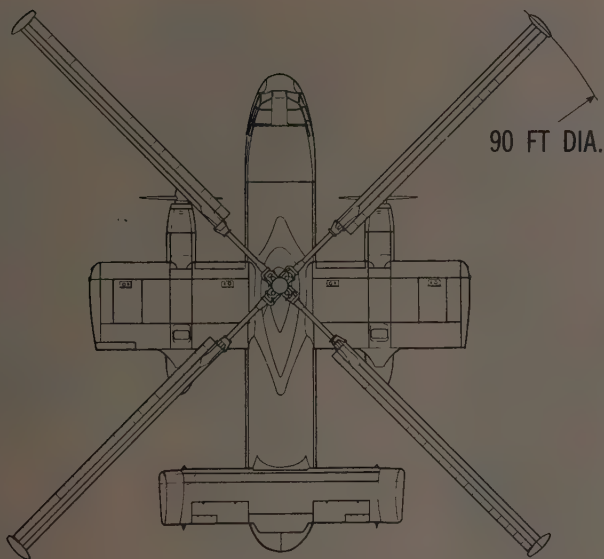
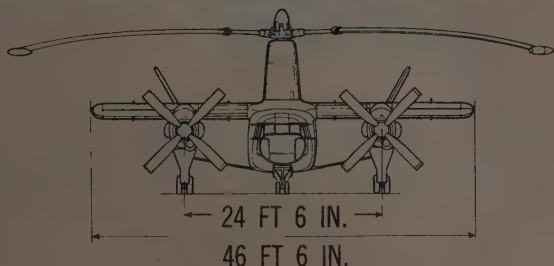
Wind effects are also eliminated during the critical first few seconds of free flight. When the missile is propelled into the atmosphere, its speed is high enough to make wind factors insignificant. Lastly, the launching sites are relatively invulnerable to even a nuclear attack, except in the event of a direct hit.

The tunnel could be adapted to fire several missiles in rapid sequence by means of a revolver-type rotating carriage, a machine-gun-type feed, or by inserting missiles one on top of the other.

While the vertical tunnel launching system was originally conceived for ICBMs and space vehicles, variations may apply equally well to smaller missiles. An installation for an area defense missile, for example, would involve a relatively short tunnel. It could be bored into a small hill or even level ground.—End

CURVES of speed and time vs tunnel length show basic parameters of "gun barrel" launching.





BASIC DESIGN of Rotodyne VTOL shown in flight and 3-view.

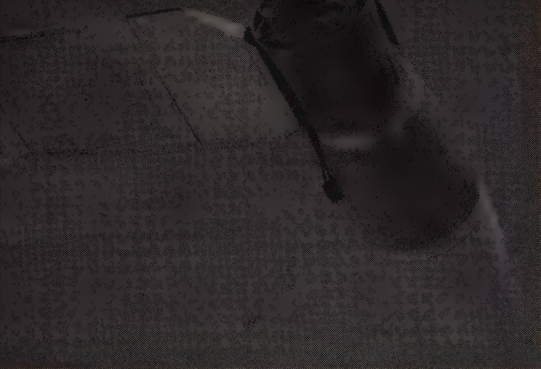
design progress



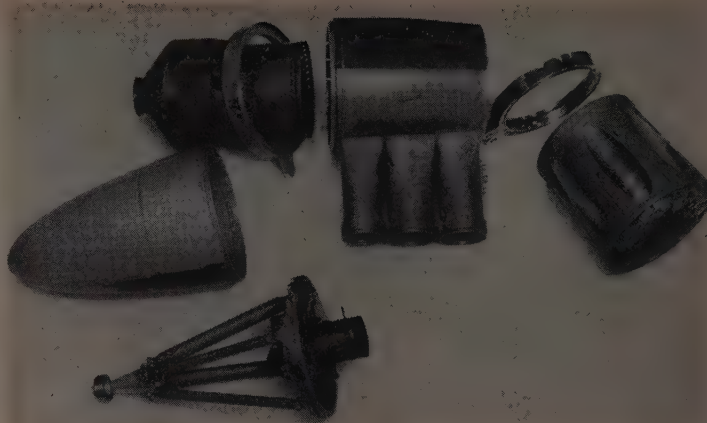
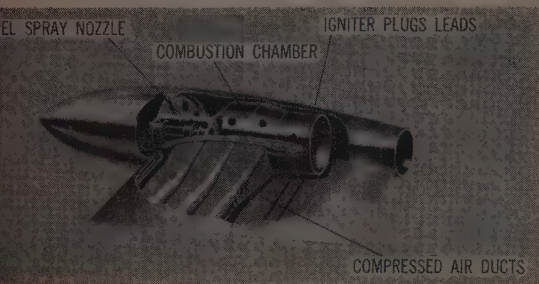
by **Randolph Hawthorne**, Editor

Fairey Rotodyne VTOL design and concept

THE ROTODYNE was designed to overcome current 'copter drawbacks for transport use. Main aims were to increase speed and size, eliminate the tail rotor, and simplify the rotor power drive. The 40-48-seat VTOL airliner is designed and built by The Fairey Aviation Co. Ltd., Hayes, Middlesex, England. Two Napier Eland N-EI-7 engines of 3500 ehp each and equipped with hydraulic clutches and auxiliary compressors and four Fairey pressure jet units of 1000 lb thrust each provide power. Cruising speed is 185 mph (about 297 km/hr). With 48 passengers at cruise speed, range would be over 200 miles. Gross weight is 39,000 lb (17,706 kg). The higher forward speed is achieved by using the autogyro method of propellers instead of tilting the rotor disk and the fixed wing to further relieve the rotor load. The pressure jets supply lift for takeoff and landing. Write in No. 51 on Reader-Service card for more information.



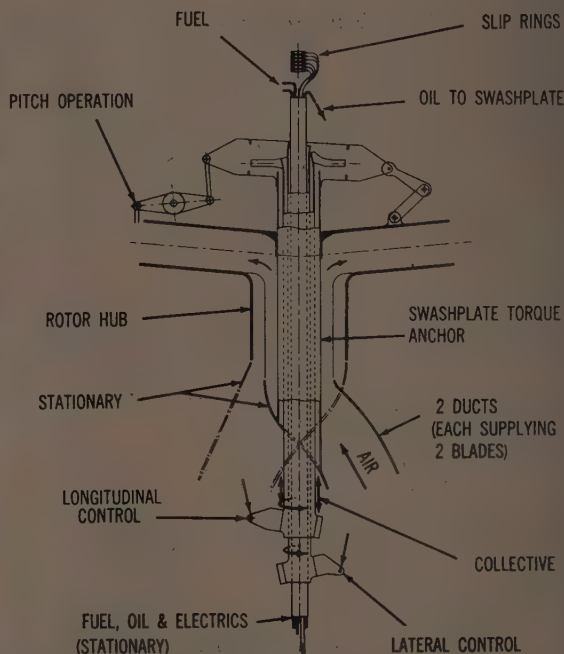
▲ **SILENCER** now used on pressure jet.



PRESSURE JETS: Pressure jet chamber is built up of machined forgings and sheet metal in Nimonic 80A. Liners are Nimonic 75. An inner liner with deep plunged holes provides a vortex pattern for the compressed air which, although asymmetric due to side entry, still guarantees equal temperature distribution and satisfactory stability over wide air-fuel ratio range down to stoichiometric mixtures for max rotor power requirement.

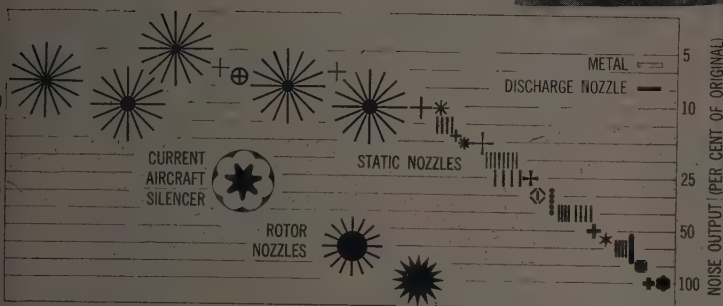


Rotor Head and Blade Construction



INFINITE LIFE was design objective in rotor head and controls. High strength steel is main structural material. Rotor head basically is a cruciform box structure made mostly from 80 tpsi steel forgings (S.99) with some steel sheet. Three compressed air ducts run through the rotor blade (bottom left).

design
progress



SILENCERS: Noise suppression results for various silencers. Over 40 nozzles were tested. It was found suppression increased with decrease in minimum width of discharge orifice. By keeping minimum width in parallel sided slot, attenuation could be predicted.



STUDY showed pressure and air-fuel ratios influenced noise from jet solely by their effect on jet velocity. Noise emission is proportional to V^n , where n is 6-7. From this, full-scale silencers were made and tested. Rotodyne silencer had to withstand 350 G and jet gases at 1800 deg C. Severe weight restriction is imposed.

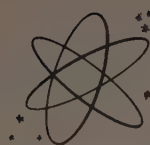


Wing and Fuselage Structures

WING is a two-spar, two-cell torsion box. It is made as a single unit, with continuous spars and no cutouts. Since each wing carries an engine nacelle, spar booms are extrusions between the nacelles. The nacelles each have four attach points (two on each spar). In addition to carrying engine loads, wing takes landing gear, pylon, and fuselage loads. It is untapered.

FUSELAGE (shown in rear view) is a stiffened, thin shell with four main longerons. Both fuselage and tail are of relatively light construction because the important flight loads are carried by the wing. Internal length is 46 ft. Width is eight feet, height is six feet. Freight loading doors at rear are clam-shell type. Floor of cabin is 3 ft 5 in. above ground.





THIN, HIGH WING and almost rectangular engine intake scoops are shown in ground shot of North American Vigilante attack plane. Dotted lines roughly indicate jowl



doors for access to plumbing and wiring. Flight shot shows hole of linear bomb bay (above and aft of engine exhausts) through which bombs or missiles are ejected.

NAA's Vigilante

uses new aluminum alloy

Navy attack plane also features:

- Bomb or missile ejection through tail hole
- Sloping engine scoops for low drag and good climb
- Easy access and fail-safe systems

by **Irwin Stambler**, Associate Editor

THE A3J-1 Vigilante, the Navy's new supersonic twin-jet attack plane, being developed at North American Aviation's Columbus, Ohio, Div., features a three-hole aft fuselage design. There are two exit nozzles for the two General Electric J79-2 engines and a linear bomb bay tunnel for stores. The craft can deliver conventional bombs, low yield nuclear weapons, or missiles by ejection through its tail.

These weapons are mounted through a 168-in.-long, non-structural door on the underside of the fuselage. The door's leading edge is just aft of the engine intake scoops. The door is attached with a series of screws. This arrangement, R. F. Walker, assistant to the gen-

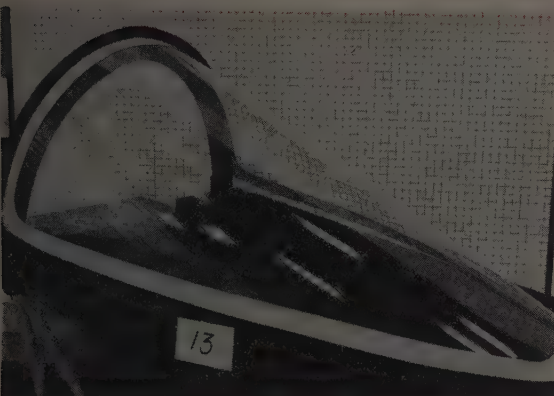
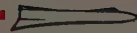
eral manager at Columbus, told **SPACE/AERONAUTICS**, solves the problem of separating stores at high speeds by doing away with the need for opening bomb bay doors.

With a screw-in door, NAA engineers point out, dead space from clearance areas needed for bomb and door operating mechanisms are eliminated. This makes it possible actually to use all the store area on the Vigilante, they claim. (The bay area can also carry extra fuel, reconnaissance gear, etc., instead of weapons.)

The basic structure of the A3J is aluminum, though titanium's used around the engines. Most of the fuselage skin of the internal structure—such as bulkheads and frames—are built-up 78ST designs.

The two main fuselage bulkheads are made of 280,300,000-psi high heat treat steel. These bulkheads serve for wing attach and to support the tail actuating assemblies. The former bulkhead also acts as a firewall behind the engines and takes the loads from the landing gear attach fitting (located just forward of it).

For the prototype A3J, the steel bulkheads were made from forgings. To save weight and cost, it was then decided to switch to bulkheads made of welded-



WINDSHIELD OF A3J is a one-piece, high temperature silicone laminate unit. It is 46 in. long and 29 in. wide.

up sheet stock. Shielded arc welding was used for this and for other high treat steel parts. About 2000 lb of the sheet stock is used on the plane.

Perhaps the most interesting feature of the structural design is the wide use of Alcoa's new 2020 high temperature aluminum alloy. The wing skins are milled from this material. The wings are of two-spar construction and serve as completely wet integral fuel tanks. The tank sealing method is similar to that on the FJ4: A groove around the full inside wing surface is filled with sealant.

The wings have boundary layer control flaps; high pressure air blown back over the surfaces. Lateral control is achieved with midchord spoiler-deflectors instead of ailerons. The wings have droopable leading edges together with the spoiler-deflectors and flaps these can be used to improve low speed flight properties.

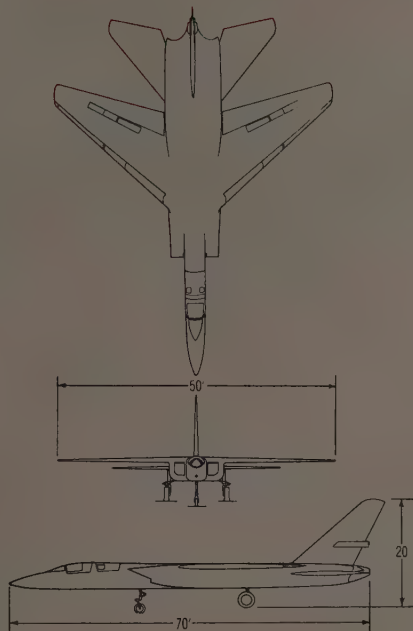
Wing sweep is 38 deg (to hold the angle of attack moderately flat for landing). The wing-tail combination is designed to give low pitch-up during carrier-type approaches. A high wing was chosen for easy carrier operation and high altitude cruise. Full power control surfaces are used.

All the tail skins are also made from 2020 aluminum, company engineers state. Tail spars and structural members are made of 78ST. Aluminum honeycomb is used for the horizontal tail trailing edge surface—as well as for wing control surfaces, landing gear doors, and air inlet areas.

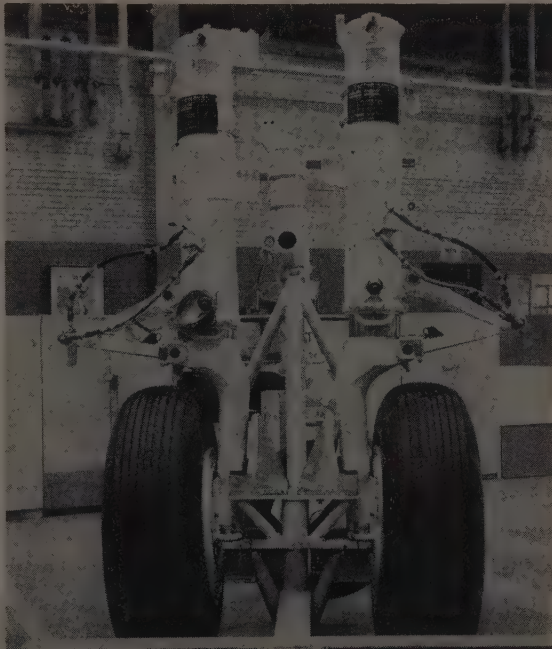
About 1000-1200 lb of titanium is used in the A3J, all in the aft-fuselage-engine area. Low cost gold plating is used on the inner titanium surfaces around the engine. The plating's reflective properties keep the metal's temperature low enough so it isn't necessary to go to heavy steel in this area. The coating is sprayed on, and the coated part is then baked.

The sharply forward-sloping, rectangular engine in-

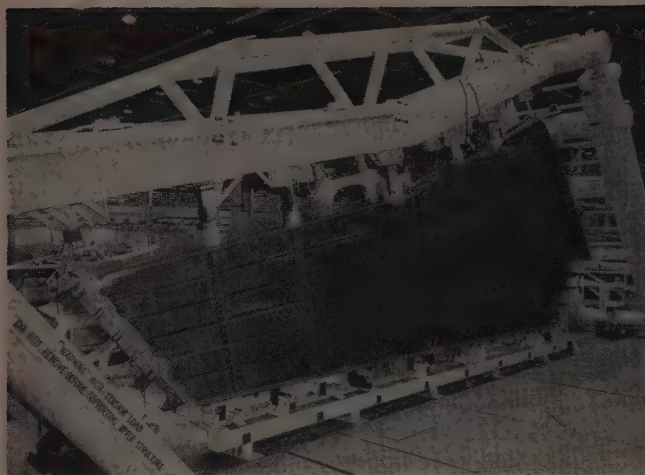
more on next page



THREE-VIEW OF A3J emphasizes stubby aft fuselage and long, thin side fuselage planform with almost flat bottom surface. The Navy plane carries a pilot and a bomber-navigator.



LANDING GEAR assemblies for A3J on assembly dolly. Main gear wheels are 36x11. Gear uses multiple-disk hydraulic brakes.



VIGILANTE WING (above) is all-wet integral tank with two main spars and stiffeners. Wing skins of production model are of high temperature 2020 aluminum. Right: Main landing gear attach assembly. Gear loads are transmitted to high strength steel bulkhead of welded sheet stock construction.

let scoop gives the best compromise for low drag and good climb altitude performance, engineers state. This design was selected after 6000 wind tunnel test hours as having the best recovery characteristics for these parameters. The scoops have movable internal ramps that are changed to meet performance needs.

The craft is trimmed laterally by differential movement of the horizontal surfaces. The fin is an all-movable slab type.

The Vigilante fuselage isn't a coke-bottle type. However, NAA engineers state that some area rule theory was used in the design. The underside of the fuselage is almost flat and has a large dive brake door. Single- or double-point refueling is provided on the side of the fuselage just forward of the speed brake.

The large main windshield is a one-piece unit. It is 46 in. long, 18 in. high, and 29 in. wide, and has a very low slope. Engineers believe it is one of the largest pieces of curved aircraft glass ever made. It is made by Libby-Owens-Ford of tempered glass with a silicone laminate to take high speeds and also the high temperatures caused by the hot air rain removal system.

Easy maintenance and fail-safe systems were key design points, Walker states. All systems—cooling, ac power, hydraulics, etc—are duplicated for safety. Every item in the plane, Walker notes, is directly accessible. In the engineer area, for example, the fuselage sides are hinged to permit work in the engines and their accessories without removal and even while the engines are running. The linear bomb bay door gives access to all equipment in its region.

Jowl doors give access to plumbing

Jowl doors are provided all along the lower sides of the forward fuselage. These give standing access to all plumbing and wiring. The electronics compartment is completely accessible through the nose gear bay via a power fold radome.

The bombing computer drops down from the fuse-

lage to give almost 360 deg accessibility. The bombing-navigation system, Walker says, is isolated from the rest of the A3J's electronics so that it can be pulled out as a unit.

The engines are removed by dropping them almost straight down. If the mechanics have the proper tools, engineers claim, it takes only 10 minutes to drop the engines and under half an hour to remove them.

All the engine tie-ins are centered in one area. A single Air Logistics' dolly can handle just about all the loading and removal functions: engine changes, weapons loading, and moving fuel tanks or other such stores into place.

Columbus officials note that the A3J is one of the most comprehensive weapon system contracts the Navy has awarded. NAA has the system responsibility for everything but the engine, which is GFAE. It is also the contractor for about \$30,000 of miscellaneous instrumentation per plane, the integrated electronic system, electronic test equipment, handbooks, the flight simulator, and the ground support equipment.

NAA's contract also provides for a fully funded fatigue test, for which a complete test plane is being built. Finally, NAA's responsible for escape system development. The escape system must be suitable for both low altitudes and speeds and high altitudes and speeds. The seat program was correlated with the T2J trainer program, data from which, it's claimed, could be applied to low speed needs. Tests included sled runs and drops of seats with dummies from balloons. The present design is a droop-canted rocket seat designed to reduce damaging effects on the pilot at high acceleration.

The Vigilante has a span of about 50 ft, an overall length of 70 ft, and a height over tail of 20 ft. Wing tips, radome, and the top of the vertical tail power-fold for carrier storage. The two J79-2 engines deliver over 15,000 lb thrust each. The landing gear has two 36x11 and one 26x6.6 wheels with multiple-disk hydraulic brakes.—End

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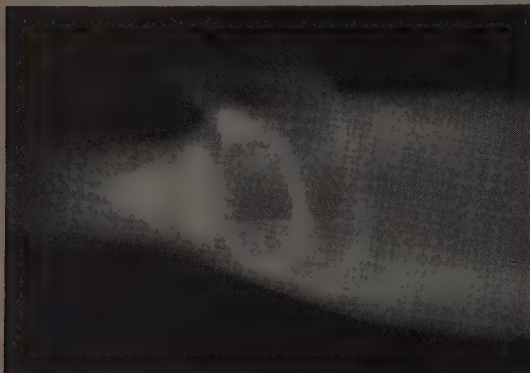
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INTERESTING by-product of rocket work at Temple University's Research Institute is the use of rocket exhaust's for re-entry studies: A scale model of a nose cone, made of refractory material, is inserted in the exhaust flame for observation of ablation.

Cyanogen and Hydrogen Cyanide Combustion*

	(CN) ₂	HCN
Oxidizer flow (pps)	0.62	0.9
Fuel flow (pps)	1	0.7
Oxidizer—fuel-ratio	0.62	1.29
Chamber gas temperature (deg K)	4860	4410
Chamber pressure (psia)	300	300
Specific heat ratio	1.29	1.29
Characteristic exhaust speed (fps)	6100	6250

*Data from tests at Temple U. with small rocket (1.1-in. throat-diameter; two-inch exhaust nozzle diameter). Oxidizers were LOX and a LOX-fluorine mixture. In tests using LOX, a small amount of liquid fluorine was injected first for hypergolic ignition.

Cyanogen and hydrogen cyanide studied for high energy rockets

Researchers are hot on the track of new propellants that will bring the liquid rocket up to its full potential. Yet there are still a good many obstacles to be overcome, as this article on advanced propellant work at Temple U. shows.

FOR some years, "avant garde" groups have been working on liquid rocket propellant mixtures that give combustion efficiencies at least 10 per cent above the values for such conventional mixtures as liquid oxygen (LOX) and kerosene. One of these groups, working at Temple University's Research Institute in Elverson, Pa., under the direction of William Doyle, has been looking into combinations of fluorine, oxygen, cyanogen [(CN)₂], and hydrogen cyanide (HCN).

Fluorine, of course, is well known as a particularly energetic oxidizer that will yield specific impulses as high as 300 seconds with a fuel such as ammonia. Because of its high density—1.7 as against 1.4 for LOX and 1.5 for concentrated nitric acid—it makes it possible to reduce the size of a rocket.

Unfortunately, it has also been discovered that, just because it is chemically so energetic, fluorine is hard to handle. Only a few seals will contain it. Copper seals have proved good for liquid fluorine in the work done by the Temple researchers. Teflon seals, their experience shows, are not as satisfactory—after some time, there is porosity and corrosion. Kel-F seals have also been used with fluorine with similar results.

As a gas, fluorine is not too corrosive if there is no moisture and can be kept in ordinary steel bottles for some time.

Over the last few years, the Elverson group has run many tests of cyanogen and hydrogen cyanide fuels in a small, water-cooled rocket. The oxidizers were liquid fluorine and mixtures of fluorine and LOX, which are hypergolic with (CN)₂.

With both fuels, there were ignition problems. In addition, Doyle's group ran into cooling troubles with HCN and poor combustion with (CN)₂. The (CN)₂ problems were solved by changing the injection rates of the oxidizer and the regenerative coolant. [The overall heat flux to the chamber walls, in-

cidentally, is four and six btu/sq in.-sec for HCN and (CN)₂, respectively.]

The combustion problems with cyanogen apparently resulted from the breakdown of this highly exothermic fuel into its elements before dissociation could take place—the reaction

$(CN)_2 \rightarrow 2C + N_2 + 73 \text{ kcal}$
occurred instead of the reaction
 $(CN)_2 \rightarrow 2(CN)$.

The Temple researchers are working on determining the heat output of the hot exhaust flames obtained with the propellants they are studying. Early data from probes placed in the first shock diamond of the flame show a value of around 50 btu/sq in.-sec. Doyle stresses, however, that this is a tentative figure.

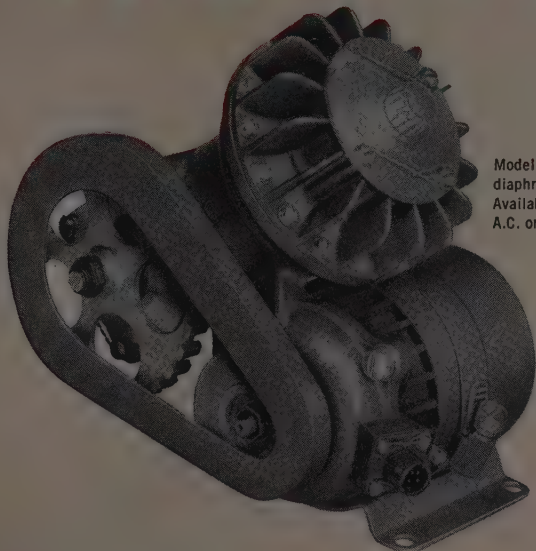
Doyle's group also is working with contoured nozzles for their rocket so that it can study shockless exhaust flames.

The tests at Elverson have contributed a good deal to our understanding of combustion at over 4000 deg K and of the heat transfer problems and chemical reaction kinetics of propellant mixtures including fluorine. Of course, because of the handling problems, neither fluorine nor cyanogen is ready for immediate use in rockets. (Both, incidentally, are poisonous.) However, the high densities of fluorine, (CN)₂, and HCN still hold out the important possibility of lower mass ratios.—KRS

more on page 64

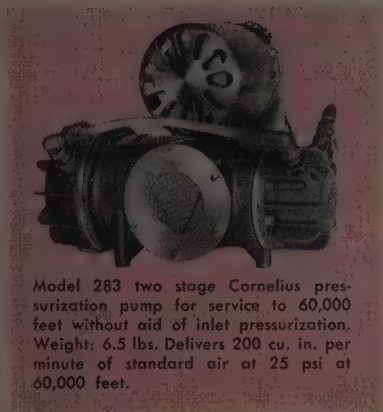
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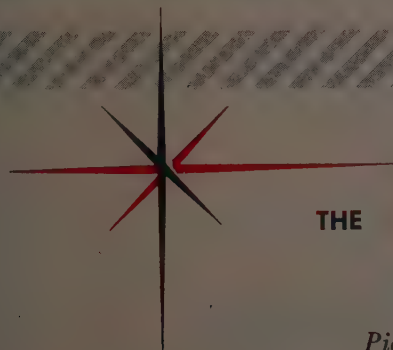


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Physical Acoustics & the Properties of Solids, by Warren P. Mason. The latest in the Bell Laboratories series, by the Head of Mechanics Research, discusses the engineering applications and analytical uses of acoustic waves in solids. D. Van Nostrand Co., Inc., 257 Fourth Ave., New York 10, N.Y. \$9.

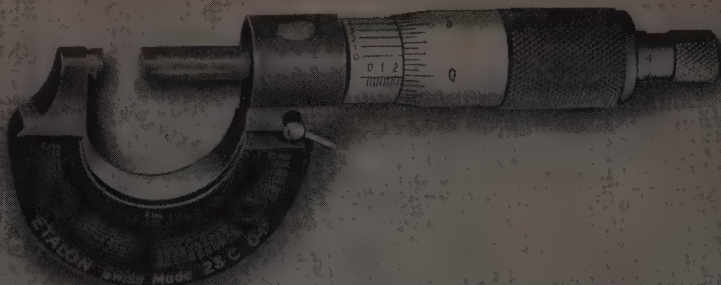
Russian-English Glossary of Guided Missile, Rocket & Satellite Terms, compiled by A. Rosenberg. Card Div., Library of Congress, Washington 25, D.C. \$2.50.

Aircraft & Missile Propulsion, Volume II, by M. J. Zucrow. This second of a three volume series deals with the cycles and performance characteristics of turboprop, turbojet, ramjet and rocket engines. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y. \$13.

Air Intake Problems in Supersonic Propulsion. This consists of the four lectures given by the combustion and propulsion panel at the 11th AGARD meeting, Paris, Dec. '56. Two of the papers are in English and two in French (with English summaries). Pergamon Press, 122 E. 55th St., New York 22, N.Y. \$5.

Gas Dynamics, by A. B. Cambel & B. H. Jennings. The theory and concepts underlying compressible fluid flow, wave phenomena and combustion are presented. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y. \$11.00.

Guided Missiles, Operation, Design and Theory. Sponsored by the Air Force, this is intended as a primer for those concerned with handling & operation of missiles as well as for training personnel for these areas. Since it covers all the major systems involved in missiles, it might also serve as a good basic reference for engineers who would like to familiarize themselves with systems, problems, etc., in areas other than their own specialty. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y. \$8.



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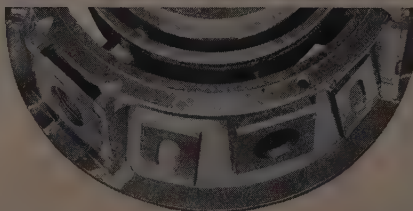
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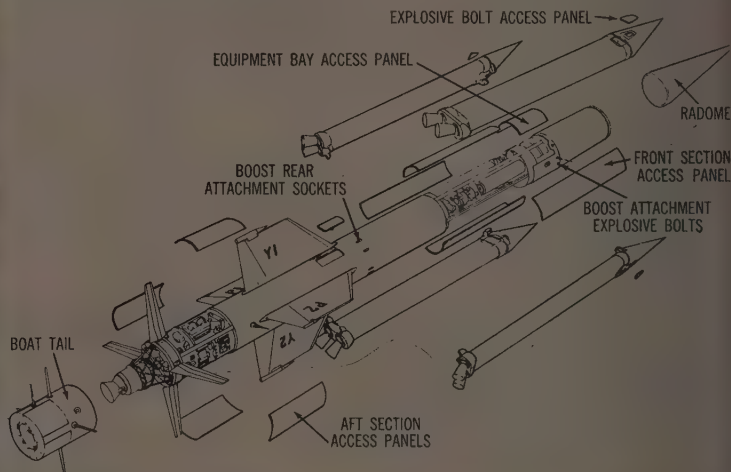
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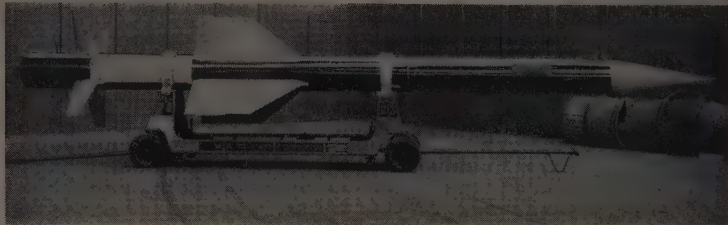
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Space/Aero Engineering

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ACCESS panels of GPV missile.



SHORT-ELLIOTT GPV test missile is used for radar homing tests. Two GPVs mounted on dollies can be transported in special truck with its own retractable loading ramp.

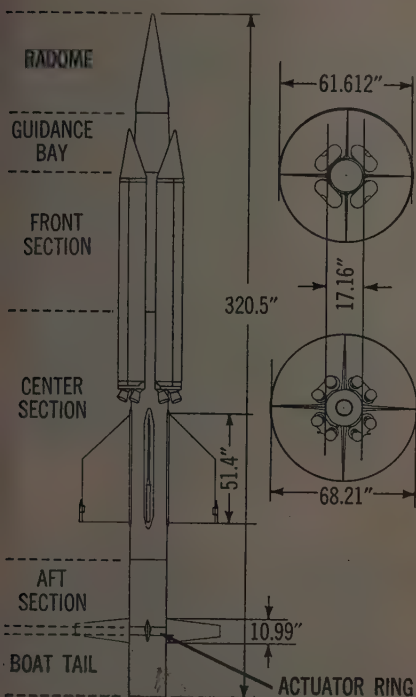
British test missile designed for easy parts access

In a way, a research missile really puts the designer on his mettle—he must come up with a “bird” that combines precision and versatility, yet stays in the low cost bracket (no research project ever has enough money). Here is how two British companies tackled this assignment in the case of a missile designed for guidance studies.

by Randolph Hawthorne
Editor

THE Short-Elliott GPV (General Purpose Vehicle) test missile was designed for basic homing research. In its present form, it has a cruciform wing and tail vane. It is powered by four pairs of boost rockets (mounted in a wrap-around arrangement) and a liquid propellant sustainer rocket. The boosters are jettisoned at burnout.

The aluminum alloy airframe is partly monocoque and partly built up of diaphragms and longerons. Wings and vanes are also aluminum alloy. The wings are cast; the vanes, machined from forgings. Access to all components is provided by easily removed panels. A conical radome



GPV PROPULSION consists of four pairs of wrap-around, jettisonable booster rockets and single sustainer rocket.

encloses the homing head in the nose of the missile.

Airframe, control surfaces and their electrohydraulic actuating mechanisms, instrumentation, propulsion, and telemetry were provided by Short Bros. & Harland Ltd., Queen's Island, Belfast, Northern Ireland. The guidance and control systems were designed by Elliott Bros. (London) Ltd., Lewisham, London S.E.13, England, as were the homing head and radome.

The GPV is used to test a semi-active homing system. A ground radar, or "lampset," radiates pulses of energy of a few centimeters' wavelength that are reflected from the target and picked up by the missile's guidance system.

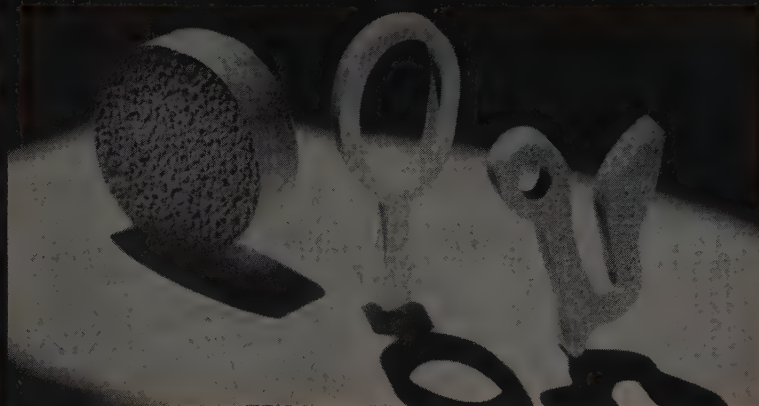
The missile's homing head consists of a conically scanned microwave radar antenna system and a conventional radar receiver. The receiver, after demodulation and smoothing, provides outputs that precess a free gyroscope in the direction of motion and at the rate of the line of sight to the target.

more on next page

Stalwart Announces

SILICONE SPONGE RUBBER

in extruded and calendered shapes

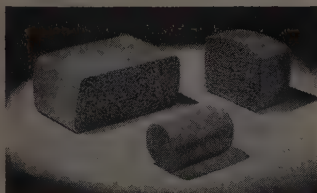


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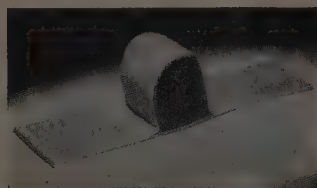
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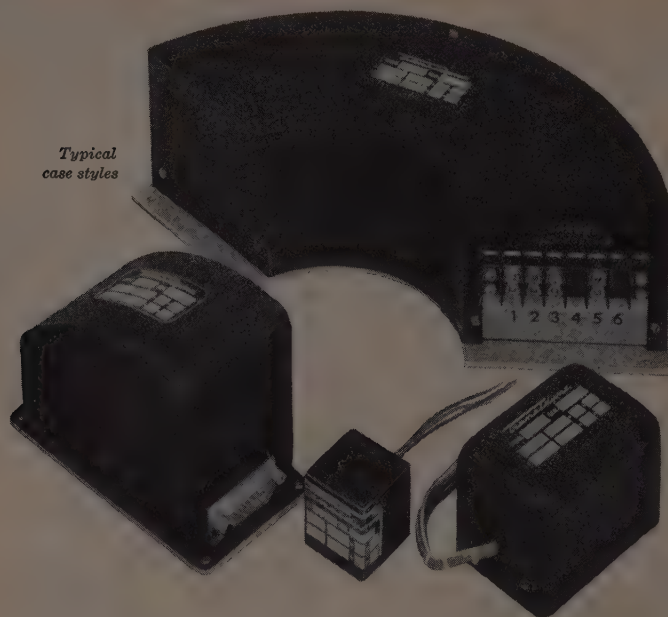
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RANGES				
Input Voltage	6.3 v to 32 v dc	6.3 v to 440 v ac (60-2000 cps)	6.3 v to 32 v dc	6.3 v to 440 v ac (60-2000 cps)
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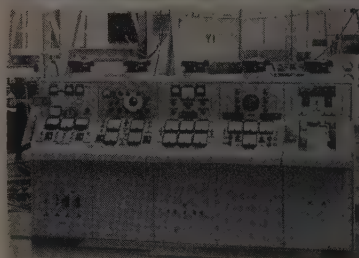
1704 South Del Mar Avenue, San Gabriel, Calif.

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TEST MISSILE . . .



RADAR homing head of GPV missile.



CHECKOUT equipment for GPV's control (top) and guidance systems.

A follow-up hydraulic servomechanism responds to signals from ac pickoffs on the gyro to keep the antenna pointing in the same direction as the gyro and so towards the target.

Gyro precession rate gives data

As the gyro axis keeps pointing to the target, its precession rate is a useful source of information for missile guidance. Signals proportional to the rates of precession of the gyro in pitch and yaw are fed

more on page 72

Firth Sterling...

PIONEER IN POWDER AND MOLTEN METALLURGY



AIR ARC



CONSUMABLE ELECTRODE
(STERCON)

INDUCTION VACUUM
(STERVAC)

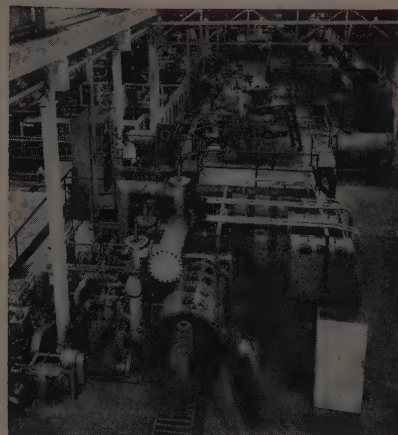


Photo courtesy Kolcast Industries, Inc.

Using Three Basic Melting Methods

to produce **tougher** high temperature alloys

Firth Sterling metallurgists have exceptional experience in *all three* basic melting methods—air arc, consumable electrode (STERCON) and induction vacuum (STERVAC)—used to produce high temperature alloys and super alloys to specification for the aircraft and missile industry. This unique combination of experience and facilities is available to you in developing high temperature materials with the purity, quality and mechanical properties essential to your applications.

For over 68 years, Firth Sterling has pioneered the development of tougher, more heat-resistant metals. The critical high temperature alloys produced for jet engine applications such as buckets, turbine wheels, shafts, compressor wheels, casings

and blades, and structural rings and support members, are examples of Firth Sterling metallurgical achievements in meeting *today's* requirements. This valuable experience, capacity and technological "know how" are being applied to STERCON and STERVAC super alloys as well as basic metals such as Zirconium.

* *

For your high temperature alloy requirements involving quality and exceptional mechanical properties call on our practical metallurgical experience and modern melting facilities. Your Firth Sterling representative will give you complete information. Firth Sterling, Inc., Dept. 15-B, 3113 Forbes St., Pittsburgh 30, Pa.

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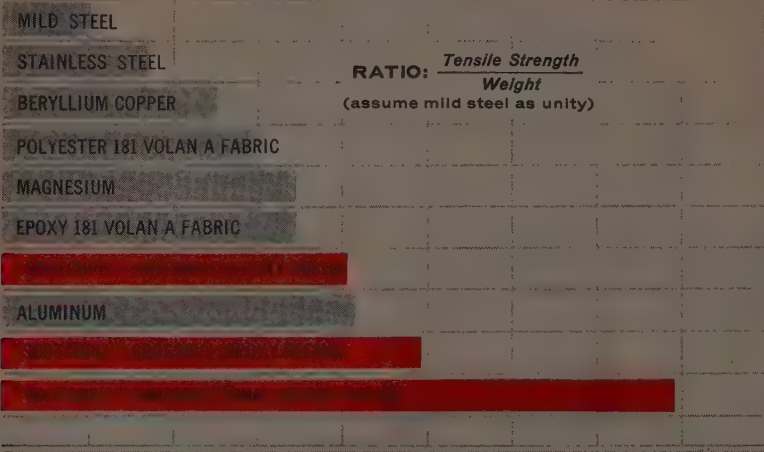
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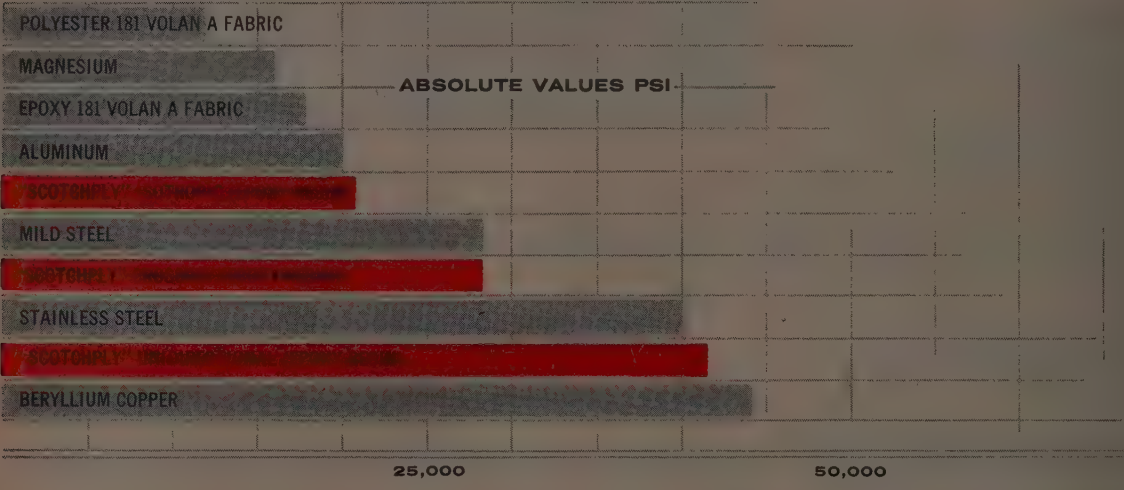


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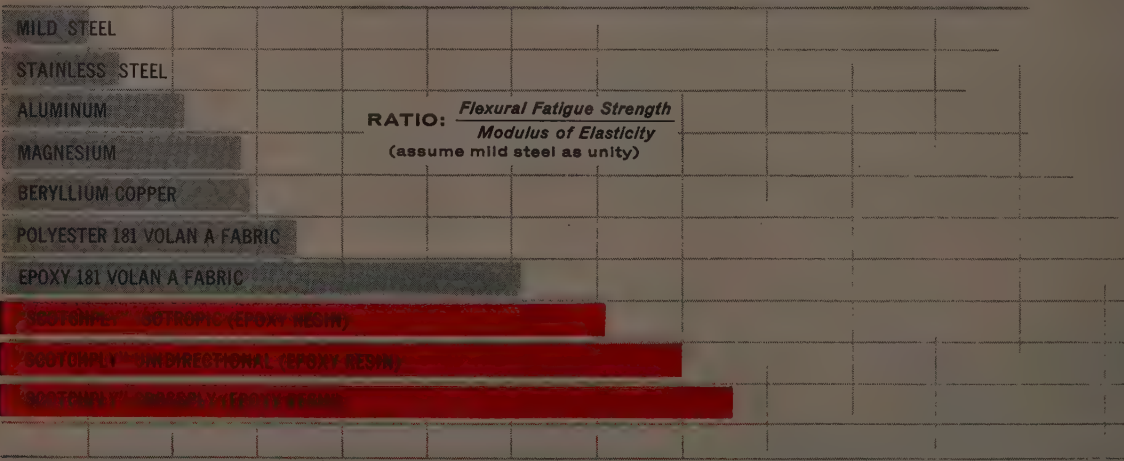
Tensile strength-weight ratios



Flexural-fatigue strength @ 2×10^6 cycles



Allowable flexural-fatigue deflection @ 2×10^6 cycles



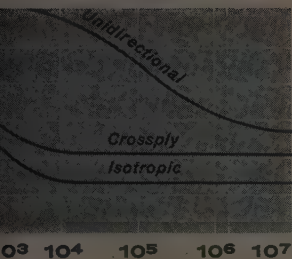
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SCOTCHPLY" flexural-fatigue



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"SCOTCHPLY" Reinforced Plastic is a moldable, laminated plastic reinforced with *continuous non-woven* glass filaments oriented to your specific stress requirements. It is available in epoxy, phenolic and other resin formulations. You get a combination of properties unlike any other structural material on the market.

Compare "SCOTCHPLY" Reinforced Plastic to other

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FOR COMPLETE INFORMATION and technical service, write on your letterhead to Dept. RX, Reinforced Plastics Division, 3M Co., 1210 University Ave., St. Paul 4, Minn. A "SCOTCHPLY" Reinforced Plastic reference manual will be mailed you without charge.



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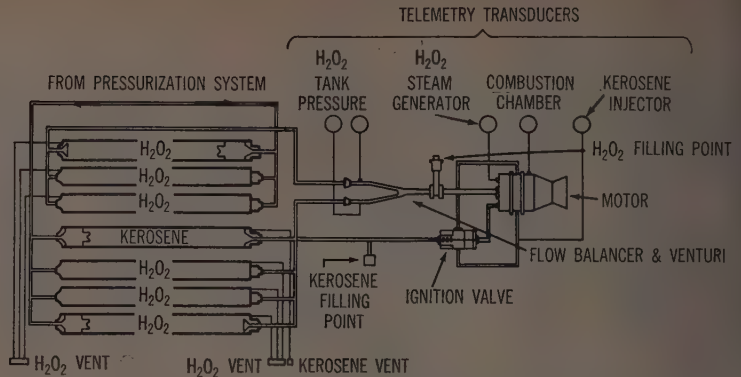
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SYSTEM diagram of GPV propulsion. Propellant tanks are in missile's center section; pressurizing nitrogen is carried in front section. Cordite may be used instead of nitrogen.

through filtering networks to summation amplifiers. The amplifiers add these demands and the autopilot feedback signals.

The algebraic sum of a demand and a feedback is fed to the two hydraulic servos governing the motions of the control surfaces in each lateral plane of the missile. Sta-

bilizing feedbacks in the autopilot are provided by rate gyros. These measure the missile's lateral rates of turn in pitch and yaw.

Roll control is provided when the control surfaces are fed differentially. The sensing element is a roll position gyro. Its signal is

more on page 74

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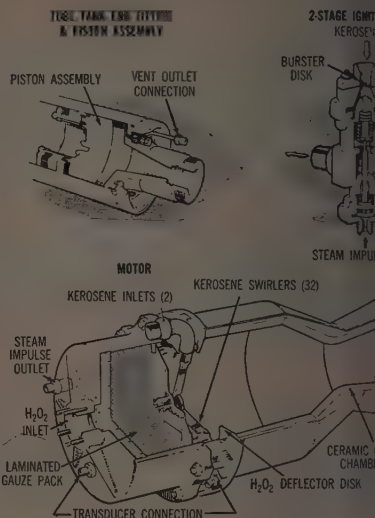
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TEST MISSILE . . .



DETAILS of GPV propulsion system.

processed by an electronic roll computer.

During boosted flight, the boost rockets are deliberately offset to spin the round and so reduce the dispersion. Meanwhile the roll computer keeps the roll rate within the range over which the hydraulic scanner can comfortably stabilize the homing head.

Best use of high-gain fin servos

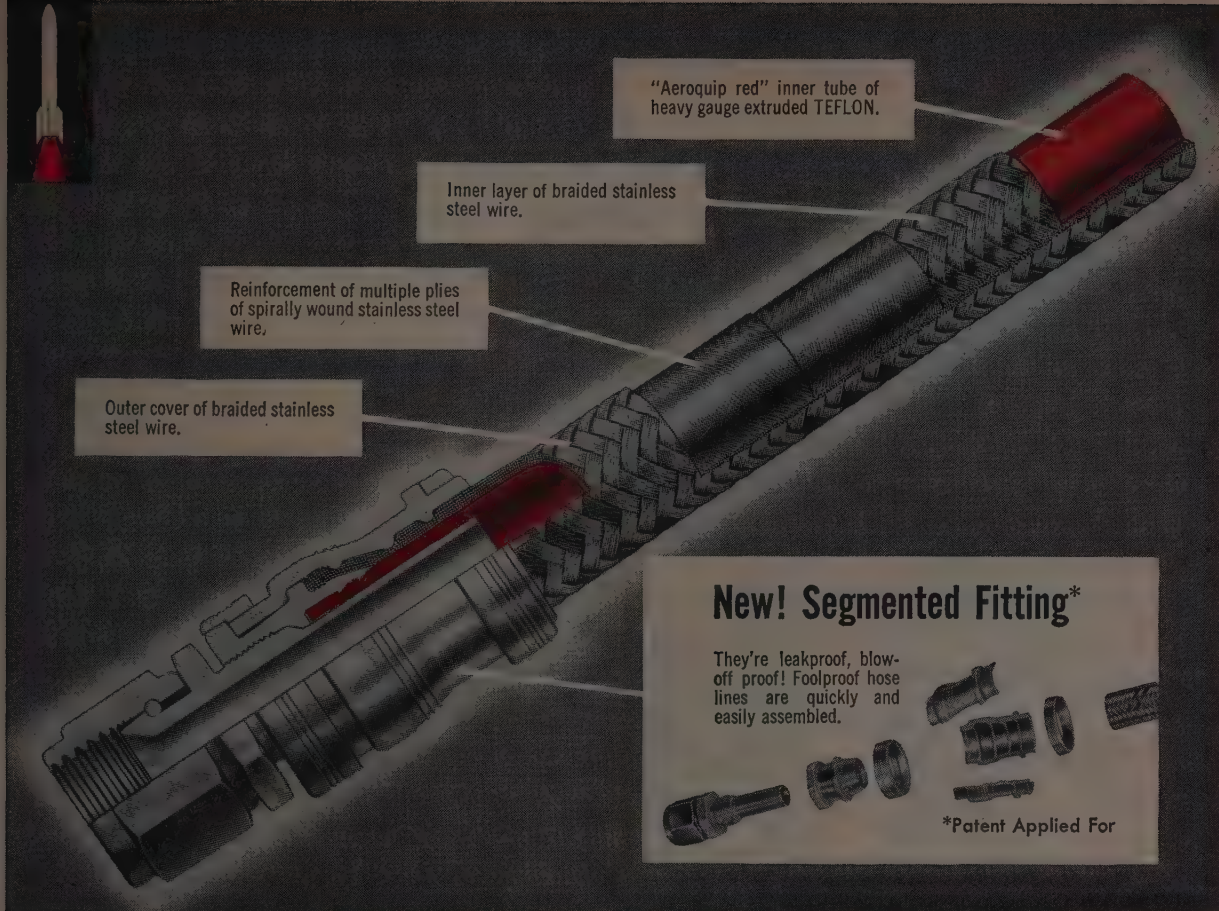
After boost separation, the roll computer operates as part of a dual-mode position stabilization loop. Position stabilization is kept over a small angular arc about the datum; outside this arc the system becomes a rate stabilization loop. This causes the round to roll at a constant rate towards the position stabilization zone about the datum.

This system is said to make the best possible use of the high-gain hydraulic fin servos without excessive transient overshoots. In addition, it keeps the round attitude in roll within extremely fine limits.

Engine system proved in firings

Seven tubular tanks in the missile's midsection carry the propellants. High pressure nitrogen for fuel expulsion is contained in the front section.

On firing the engine, H_2O_2 is fed
more on page 78



BURST PRESSURE

24,000 psi.!!

OPERATING PRESSURE: 6000 psi.

AEROQUIP ANNOUNCES VERY HIGH PRESSURE 678 PNEUMATIC HOSE LINES OF TEFLON

Aeroquip makes a major contribution to safety in the handling of very high pressure air, helium, nitrogen and other gases for missile charging systems. Newly developed and now available is rugged 678 Hose of TEFLON, rated for 6000 psi. service . . . with a 4-to-1 safety factor!

With an inner tube of TEFLON, which has zero moisture absorption and an anti-adhesive surface, Aeroquip 678 Hose allows fast, easy purging and dehydration. The hose has superior resistance to vibration, low volumetric expansion and high temperature resistance. Return the coupon for complete information.



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Aeroquip 678 Pneumatic Hose of Teflon . . .

Hose part number	678-6	678-8
Hose size I.D.	.312	.437
Hose size O.D.	.609	.812
Oper. press., psi.	6,000	6,000
Burst press., psi.	24,000	24,000
Bend radius at pressure	5	10

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Aeroquip Corporation, Jackson, Michigan

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S/A-2

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Announcing...

9% Nickel Alloy Steel

for the world's coldest applications
down to -320°F

Nothing gets much colder than liquid nitrogen, which exists at temperatures of minus 320°F and below. At such temperatures, most container materials get brittle—lose their toughness.

To meet the need for an economical material that can be used for low-temperature pressure vessels, U. S. Steel is making an alloy steel containing 9% nickel. This steel is stronger, tougher and less expensive than other metals used for handling liquefied gases such as methane, oxygen, and nitrogen. For test purposes, plates in thicknesses of $\frac{1}{4}$ and $\frac{1}{2}$ inch are ready for immediate delivery. Sheet sizes and heavier plates, as well as structural shapes, bars, and semi-finished products, are also available upon inquiry.

Higher Strength. USS 9% Nickel Steel can be furnished to meet all requirements of ASTM Specification A-353, Grades A or B. The ASME Boiler and Pressure Vessel Code allows a maximum working stress of 22,500 psi for 9% Nickel Steel. This is about 17% higher than allowed for other metals used for this purpose.

Greater Toughness. The toughness of 9% Nickel Steel has been well established in drop tests of actual vessels containing liquid nitrogen at minus 320°F . Charpy keyhole-notch impact values have been observed to be as high as from 31 to 38 ft.-lbs. at minus 320°F , from 73 to 84 ft.-lbs. at room temperature.

Weldability. Joints of 100% efficiency are possible with either manual or automatic welding in the inert gas metal-arc process. Suitable welding rods are available.

Weight Reduction. Greater strength permits USS 9% Nickel Steel to be used in thinner sections with substantial weight reduction. This is important for stationary storage and shipboard storage tanks for methane—and for other severe low-temperature storage applications.

Lower Costs. The steel itself costs less than competing materials by about 40%—and products such as tanks and heads can be made stronger with less material.

We urge you to consider USS 9% Nickel Steel for better, less expensive low-temperature vessels.

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 **United States Steel**

to the motor through a silver gauze catalyst and decomposed into superheated steam and oxygen. Pressure from the steam opens the kerosene valve, and the kerosene is injected into the combustion chamber through a number of atomizing nozzles. Combustion is spontaneous. The engine system has proved completely reliable in many firings, it is claimed.

High pressure nitrogen runs alternator

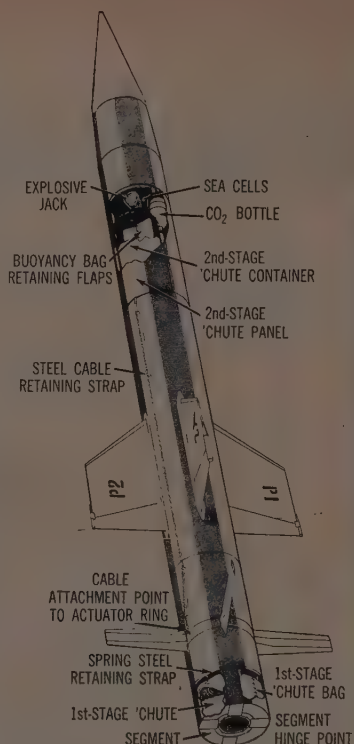
High pressure nitrogen is used to pressurize the oil for operating the electrohydraulic fin servos. It also is used to run the turbo alternator that—through suitable power packs—provides the electric supplies for guidance, control, and instruments.

The GPV's instrumentation now includes:

- two pulse-modulated FM-AM telemetry transmitters using FM subcarriers with time divisions to provide 48 information channels (including synchronization and calibration);

- a telemetry transmitter, oper-

more on page 80



RECOVERY installation of GPV missile.



Cessna Model 150 . . . two-place tricycle geared high wing airplane for training, rental, pleasure, and general utility use.



Model 172 . . . Cessna's basic four-place economical business airplane.



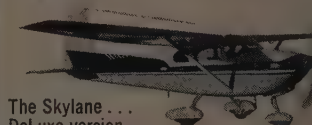
Model 175 . . . Offering the replacement market improved performance in an airplane of medium price.



Model 180 . . . High-performance airplane using conventional landing gear for short, rough fields, and also adapted to use skis or floats.



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Model 310C . . . Top of the Cessna line, adapted to the needs not only of the individual customer needing a light twin, but to those of fleet users as well. Offered as delivering the finest overall performance in the entire light twin market.

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FC-3510	1.5"	2.09"	.31	Synthetic oil	Military and Commercial Hydraulic Reservoirs
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The Gabb Adapter and Cap Unit, Tank Filler, is the first 3 inch assembly to successfully pass all the requirements of specification of MIL-C-7244 B (ASG). It is applicable to fuel, oil, water-alcohol and hydraulic reservoirs. This self-contained, flush mounted unit permits tank pressure relief by means of a lever action handle prior to removal of the cap from its adapter. Subsequent removal of the cap requires only a 35° rotation of the same handle. Write for free brochure No. 435.

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SPACE/AERONAUTICS

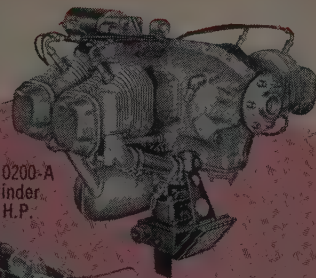
In the Cessna Line it's CONTINENTAL

..All the Way!

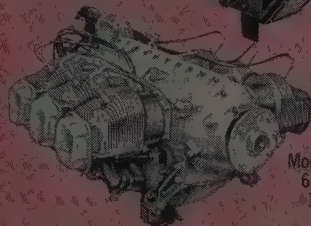
• The owner of every Cessna airplane benefits not only from its builder's unsurpassed experience in airframe design and construction, but also from Continental's pre-eminence in the field of aircraft power. All seven models in Cessna's line, from the economically-priced 150 to the 5-place twin-engine 310C, offer the plus value of the engine that has long been pilots' first choice. Continental has earned this preference solely on the basis of performance. Today, as in the past, every major flying record* at the utility aircraft level is Continental-held.



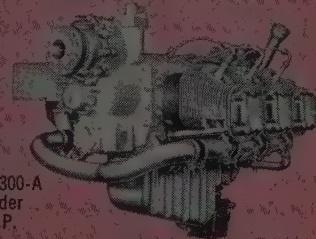
*The latest is that established by Jim Heth and Bill Burkhart, at Dallas, in their Cessna 172 with Continental O-300-A engine. They stayed aloft from Aug. 2 to Sept. 21, 1958—1,200 hours, 16 minutes—flying a distance equivalent to four times around the globe. Both the record they broke, and the one before that, were set by planes with Continental power.



Model O200-A
4-cylinder
100 H.P.



Model O300-A
6-cylinder
145 H.P.

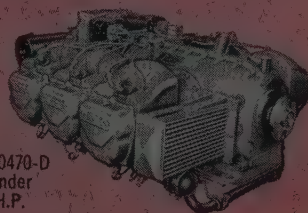


Model G0300-A
6-cylinder
175 H.P.



Model O470-L
6-cylinder
230 H.P.

(O470-K differs from O470-L
only in carburetor location)



Model IO470-D
6-cylinder
260 H.P.

Continental Motors Corporation

AIRCRAFT ENGINE DIVISION
MUSKEGON • MICHIGAN

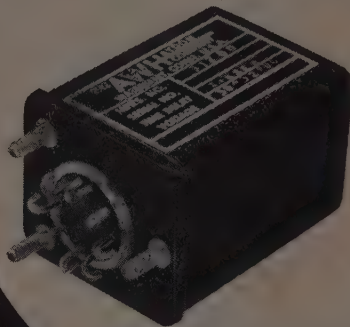


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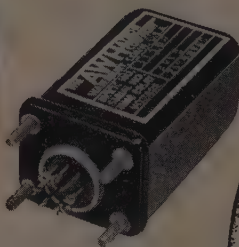
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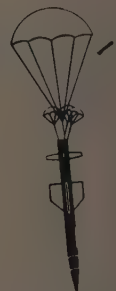
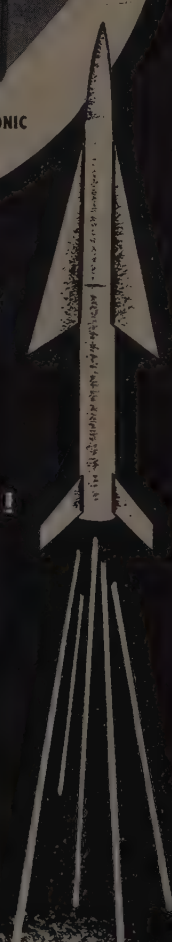
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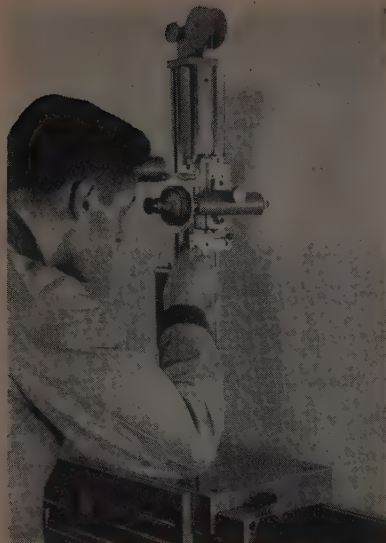
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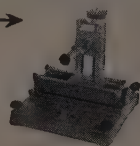
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Horizontal range 6",
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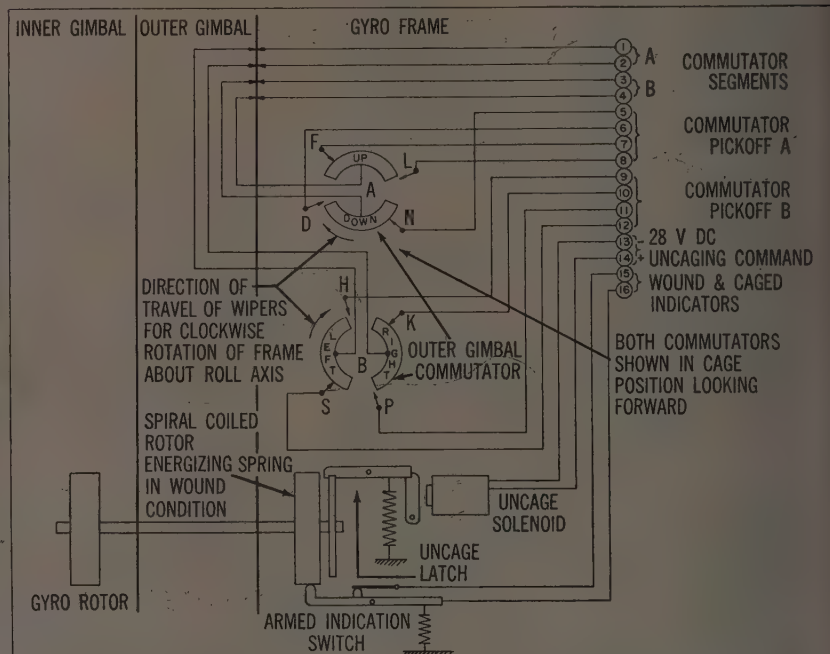
M1236-22—
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The Gaertner Scientific Corporation

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Write in No. 20 on Reader-Service Card



ELECTROMECHANICAL schematic of spring-driven gyro shows details of latching mechanism and armed-fired signal circuit. Both commutators are shown in caged position and looking forward; energizing spring, in wound condition; and switches, in caged position.

Spring-driven gyros have low drift rates

Until recently, spring-energized gyros were limited to short-duty-cycle applications—as in a recent air-to-ground missile, where the allowable drift rate is 0.625 deg/min. In design are units that will have the same drift rate averaged over an operational life of 10 minutes.

by **Kenneth W. Brown**

Project Director, Whittaker Gyro Division, Telecomputing Corp.*

INSTEAD of being electrically driven, the rotor in a spring-energized gyro is spun up to operational velocity by a frame-mounted spring. The gyro is ready to go any time—without any electric power supply or prelaunch warmup.

Spring-energized gyros have been used in the defunct Army Dart and a current air-to-surface missile. The same basic position gyros are being considered for other short range, high speed missiles and for target drones. For such advanced applications, the drift rate can be kept well within tolerable limits of no more than

*Whittaker Gyro Div., Telecomputing Corp., 915 N. Citrus Ave., Los Angeles 38, Calif.



SIMPLE winding, latching, and release device in spring-drive gyro—shown in the energized position—consists of a ratchet on the spring arbor shaft, a pawl, an impact hammer to release the pawl, and a small latch release solenoid.

0.625 deg/min averaged over a fully effective 10-minute control period.

Even more advanced versions of the spring-wound gyro are in design. One subminiature unit is intended for two-axis control during a boost operation control period of 10 seconds.

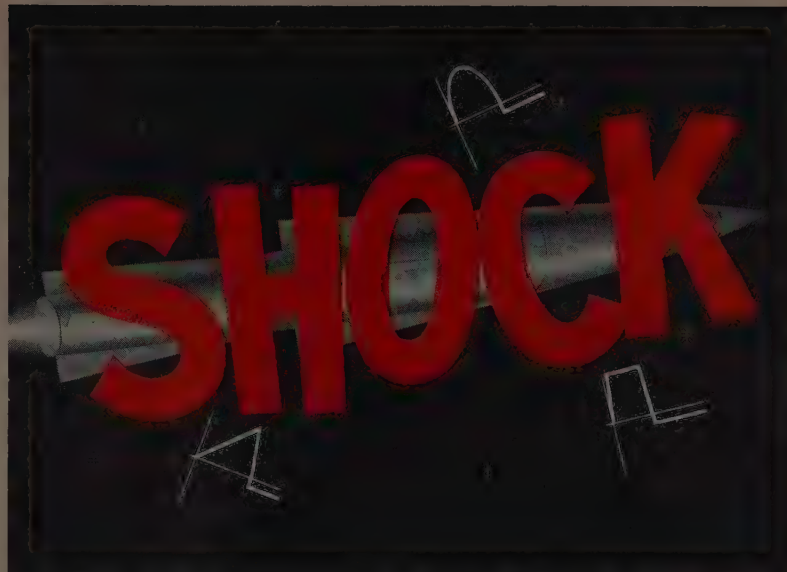
Preliminary studies are also being made of a design to withstand over 1000 Gs. This application would be for extremely short control periods.

Spring-wound gyros are quite simple mechanically and operationally. A ratchet and pawl arrangement is used to lock a spiral, coiled "clock" spring in the energized position. When released, the spring unwinds and imparts its energy to the gyro rotor.

A typical gyro rotor reaches its maximum speed of 10,000 rpm in less than 100 millise. Its angular momentum is 1-1/3 million g-cm/sec². Synchros, potentiometers, and commutators have been used as pickoffs.

Higher velocity gyros have been built. However, bearing friction and windage losses mount sharply when the rotor speed goes over

more on next page



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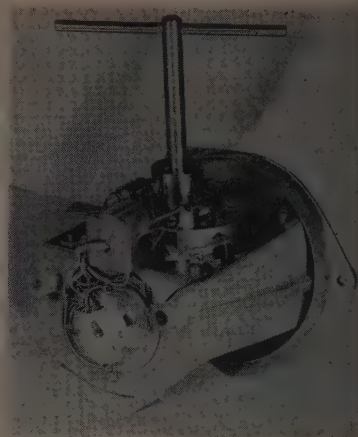
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SPRING-DRIVEN GYRO . . .



REMOVABLE key is used to cage and wind the gyro. The commutators are shown in position on the outer gimbal pivot.

10,000 rpm. The result is that, when the rotor starts coasting, its deceleration rate is high. By using large wheels and sticking to speeds under 10,000 rpm, it is possible to flatten out the deceleration curve and keep the angular momentum more constant.

The gyro is caged manually by removing the cover and aligning the gimbals to the caged position. It is wound, or armed, with a removable key.

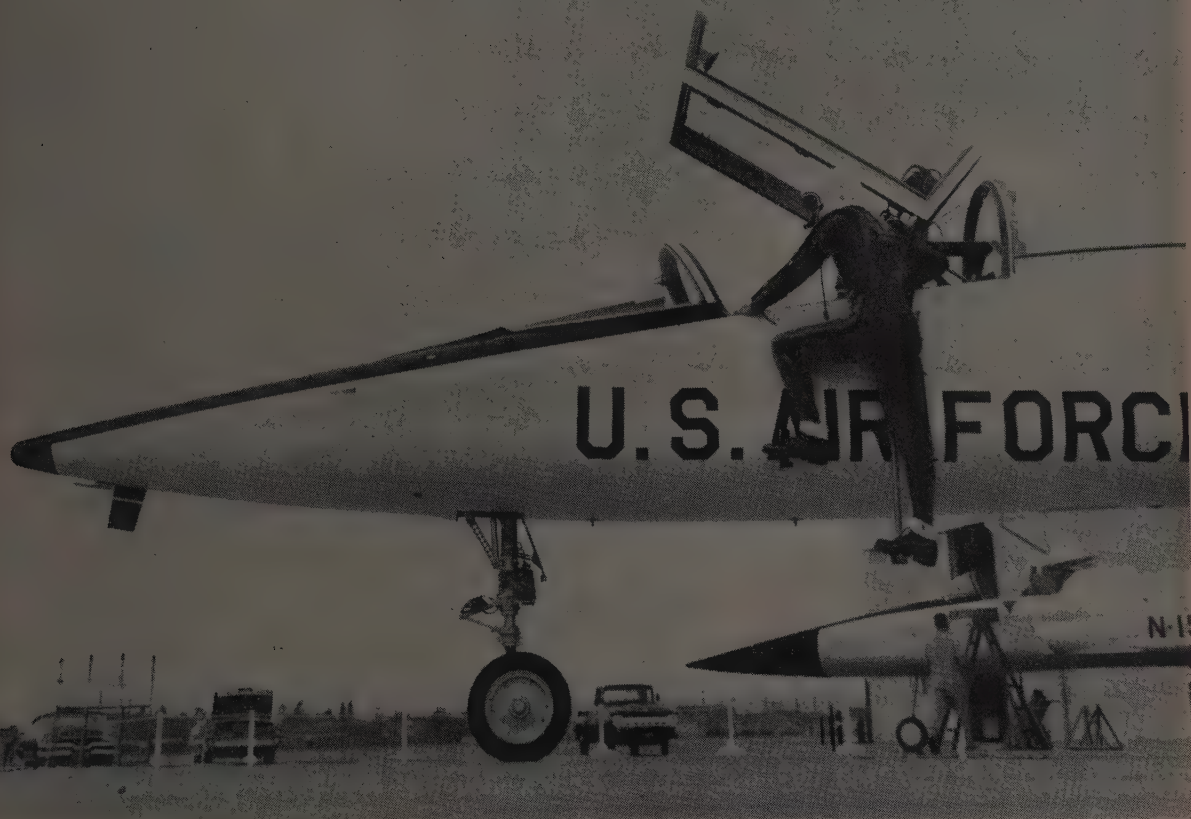
Once armed and hermetically sealed, the gyro will remain ready for instant energizing over an extended period. Spring tension is not too critical. A mild set has no adverse affect on rotor acceleration.

A five-ampere, 28-V dc signal is enough to activate the starting solenoid. An impact hammer is then released, which disengages the pawl that holds the spring arbor in the armed position. Once released, the spring tension is transmitted as energy to the rotor shaft.

For repeated proving tests, the gyro may be manually recaged, the spring rewound, and the case replaced without any adverse affects on accuracy. Specs call for the gyro to withstand at least 25 full operational cycles. Actually, units have been cycled for many times higher values without any loss in accuracy. Write in No. 52 on Reader-Service Card for more information.—End.

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The twin-jet T-38 pioneers a new Northrop family of low-cost, high-performance aircraft. Another member, Northrop's N-156F NATO-SEATO counterair fighter, is now being built at Hawthorne, California. Final mockup of the N-156F is shown in background of above illustration.

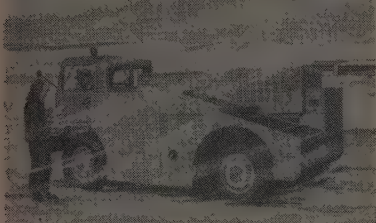
Both aircraft are evidence of Northrop Division's skill in creating and producing higher quality products at lower cost. With other current projects, the T-38 and N-156F illustrate a new kind of cost-conscious creativity—are results of Northrop's budget-minded management team, the unique Performance and Cost Evaluation Program called PACE, and of Northrop-developed production techniques.



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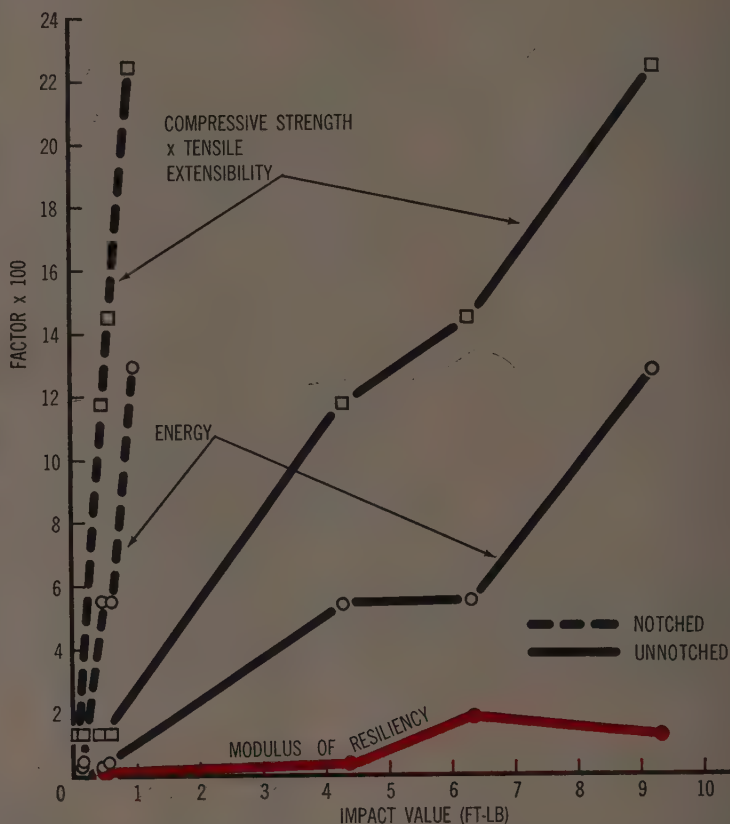


FIGURE 1: Various factors from NBS cermet tests vs impact values.

New test methods give reliable cermet data

Few things frustrate designers more than an obviously superior material that they can't use just because there are no adequate data on its mechanical properties. It's good news, therefore, that the Bureau of Standards has developed test methods that yield reliable data on brittle cermets.

THE lack of reproducible data on brittle cermets has hampered the use of these materials in missile designs. For example, Young's modulus of elasticity often varied in relation to other elastic properties, depending on whether it was obtained in tensile, compressive, or transverse tests. Therefore, the Army asked the National Bureau of Standards, Washington 25, D. C., to evaluate the methods



GRIPPED-END tensile specimens proved best for tests of brittle cermets. In this setup, NBS measured strain with an optical gage mounted on the reduced part of the specimen and read it through colimators (at right and left).

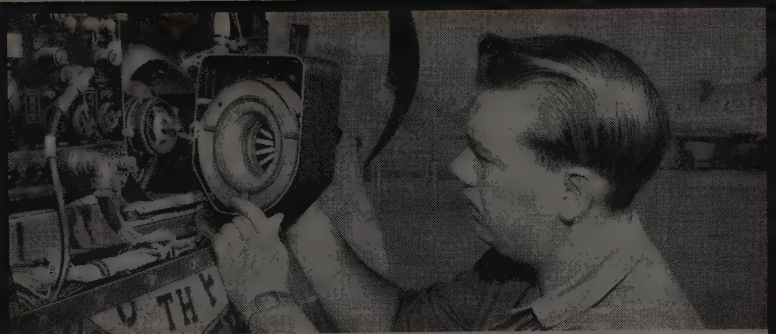


TORSION test setup for cermets uses optical twist gages to measure angular deformation of specimen (C) with the help of autocollimators (A & B) and a right-angle prism (D).

commonly used to find cermet properties and try and come up with ways to get more reliable data.

A major reason for the disagreement among experimental results for ceramics is their brittleness. This calls for more refined procedures and improved test apparatus than can be used in the study of ordinary ductile materials. Another factor, it was found, is the difficulty of obtaining correct stress distribution, since ex-

more on next page



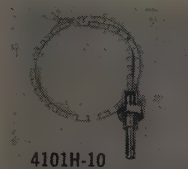
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CERMET DATA . . .



TRANSVERSE test loading setup at NBS uses spacer (A) for supports (B & D) of the test specimen (C). The load applied by the crosshead (H) is transmitted to a beam (G) and then to the specimen. Parts (D, E, F) with rocker bases prevent extraneous stresses in the specimen. Magnets (K) position the parts.

traneous stresses are easily introduced.

These points were specially considered, to eliminate errors from the final strain gage determinations. For instance, NBS scientists studied several tensile test specimen designs. These differed mainly in the provision for applying load. The pin-end type, with a hole at each end to allow mounting, previously considered adequate for tensile tests, was found unsatisfactory because of excessive stress concentrations. Although other designs were suitable, too, the final results of the program showed that the gripped end design, with specimens grooved at the ends, was best (Fig. 2).

New equipment gets rid of side effects

A particular mounting arrangement was adopted for compressive tests, because of the difficulty of getting good alignment. The usual ways of aligning the specimen, such as spherical bearings or a cast-in-place layer of plaster of Paris, gave a non-uniform stress distribution. In some cases, NBS states, one side of the specimen was actually in tension.

more on page 90

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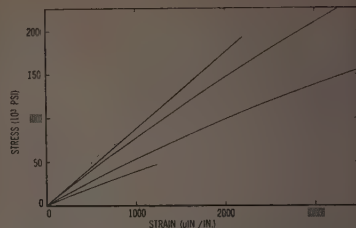


FIGURE 2: NBS stress-strain curves for four gripped-end, tensile cermet test specimens.

Successful alignment was obtained with specimens having parallel ends set between flat bearing blocks on anvils to which the load is applied. To eliminate another source of error, very hard bearings were used to prevent specimen penetration. These were re-ground after each test to remove roughness.

In torsion tests, it was found that there is often some bending of the specimen, which causes inaccuracies. To make sure the measured stresses would be due to twisting only, a special machine was developed. It has a frame that is symmetrical about the specimen axis.

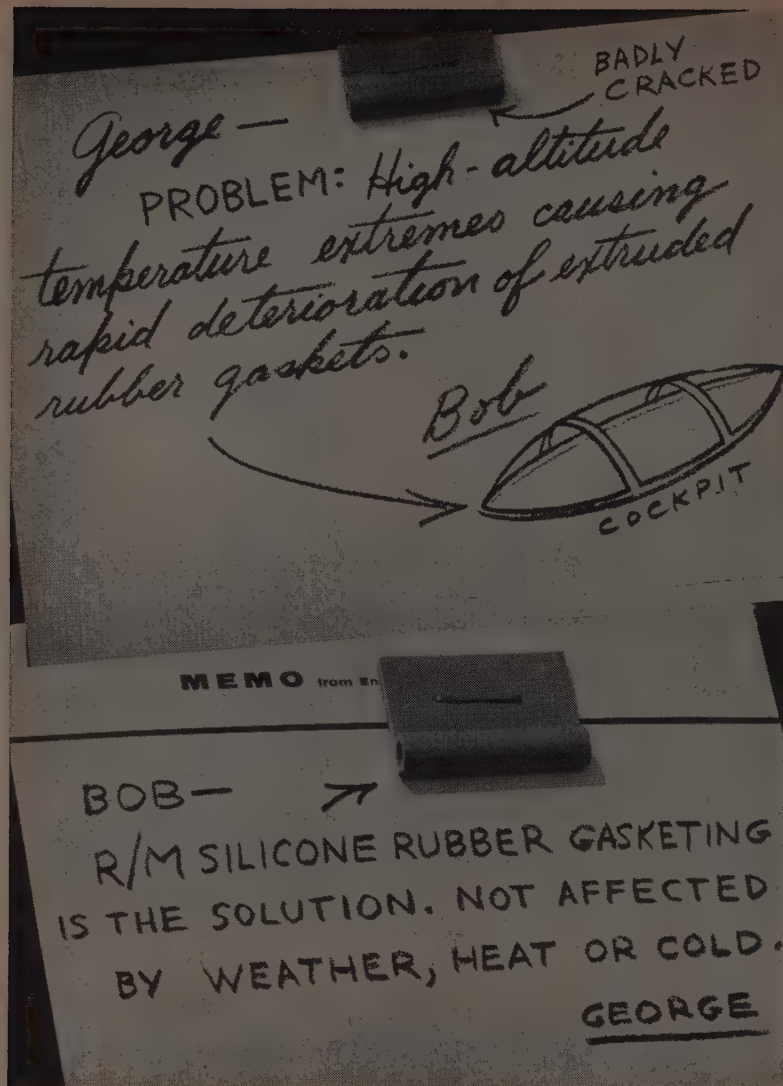
Equipment to prevent undesirable stresses was also designed for the transverse test. In this case, rocker bases eliminate stresses due to causes other than simple bending.

The correlations of results from the modified tensile, compressive, torsional, and transverse tests, NBS scientists report, indicate that satisfactory elastic properties can be obtained from each. The only exception was Poisson's ratio for which stubby transverse specimens gave values that were too low.

Tensile and comprehensive tests preferable

The NBS comparison of the four tests showed that all are about equal in complexity and cost. The tensile test has the advantage of yielding tensile strength directly (without corrections for plasticity or creep). The compressive test has the same advantage for shear strength determinations. The researchers, therefore decided that these two tests are

more on page 92



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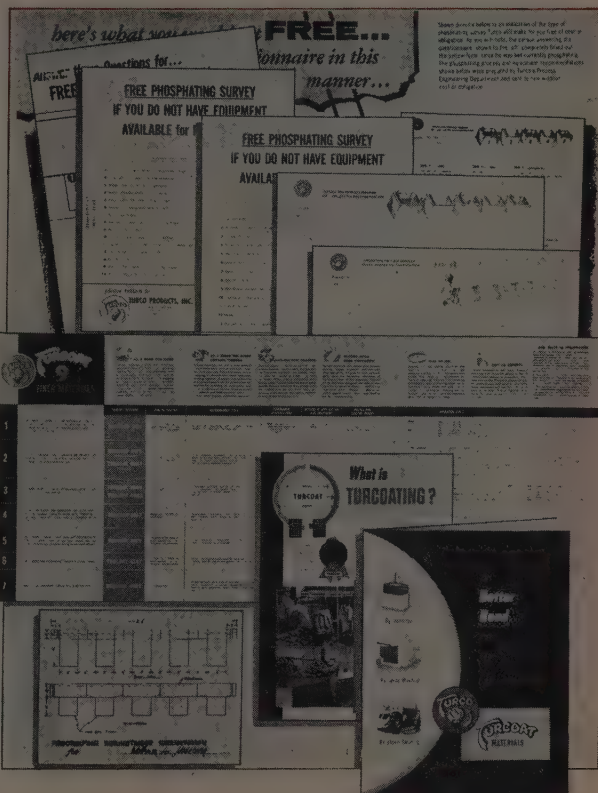
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Photo courtesy of Trailmobile, Inc.



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CERMET DATA . . .

preferable for finding significant mechanical properties.

The other two tests are most useful in design problems that include bending and twisting applications. Tensile strength may also be calculated from the transverse and torsional strengths, NBS reports, by making corrections based on surface measurements.

In an attempt to correlate the results of impact tests with the mechanical properties of cermets

determined from other tests, the researchers studied the performance of materials subjected to sudden loading (Fig. 1). Since the energy causing fracture is only a small fraction of that which can be stored without fracture at low loading rates, stress concentrations were thought to be excessive. Although several correlations were tried, the impact value couldn't be predicted with any accuracy from other tests.—IS

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SPACE/AERONAUTICS

OSTUCO *Fabricated Welded Tubing*



FOR ECONOMY

Bending vacuum cleaner wand. A variety of fabricating operations also is performed on Ohio Special Quality Seamless Tubing.

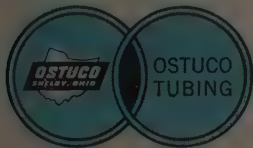
“Value analysis showed it would be more economical to buy than produce fabricated welded tubing parts for our new cleaner. What's more, we could avoid additional capital investment in equipment.

“So we added Ohio Seamless to our production line. They have the equipment and facilities to meet our design requirements and to hold to our stepped-

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How Lockheed helps conserve defense dollars:

The missile with 9 lives

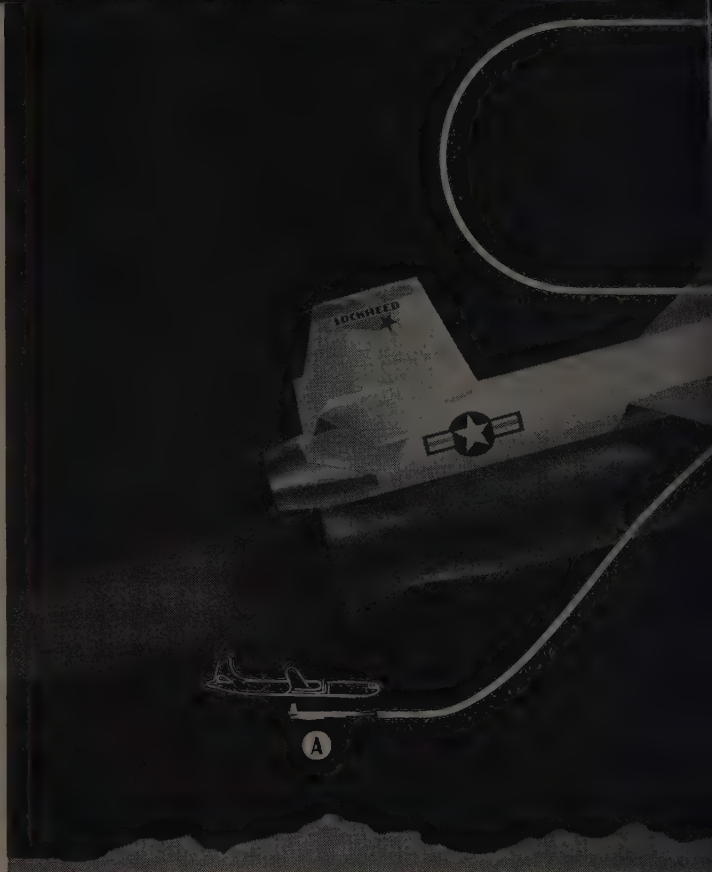
The U.S. Army's new Q-5 *Kingfisher* was designed by Lockheed's Missile Systems Division to provide our mighty arsenal of ground-to-air missiles with a realistic test of marksmanship—against high-altitude targets moving at supersonic speeds over 1500 miles-per-hour.

The *Kingfisher* is 38-feet long, 20-inches in diameter, has a 10-foot wingspan and weighs more than 7600 pounds. As it flashes across the skies it electronically simulates any desired size and type of "enemy" plane or air-breathing missile.

The *Kingfisher's* electronic Firing Error Indicator instantly and accurately tells ground controllers whether missiles fired at it are "hits" or "misses"—and automatically evaluates each missile's angle-of-attack, miss-distance, and other highly important technical data.

Undamaged by "hits" scored on its electronic image, the Q-5 *Kingfisher* is parachute recovered after each flight.

This Lockheed-developed "missile with 9 lives" will enable the U.S. Army to achieve hitherto impossible proficiency in missile marksmanship against supersonic targets—at a saving to taxpayers of approximately half a million dollars on each recovery flight.

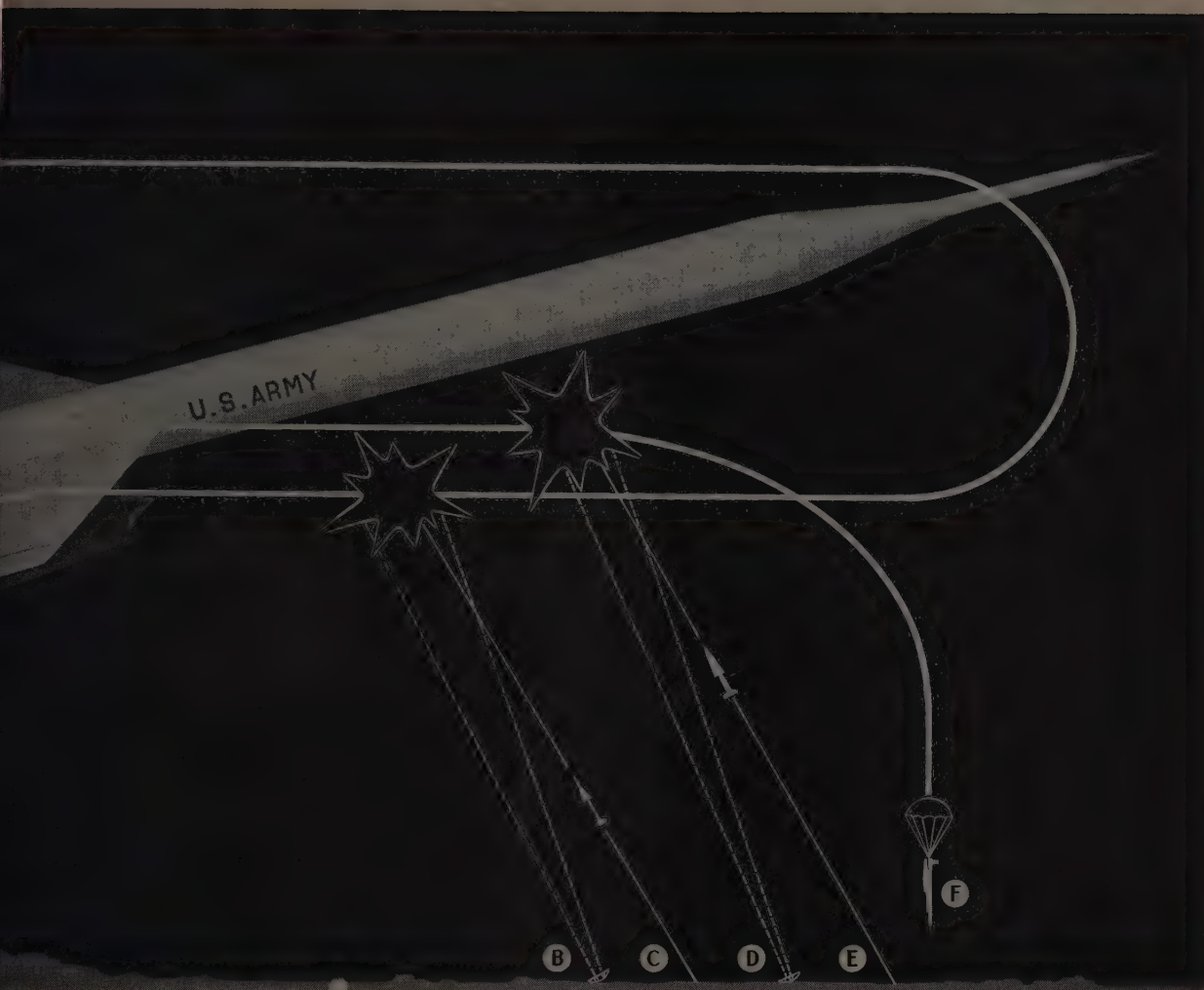


Q-5 is dropped by plane at 35,000 feet ((A) in diagram). Then its twin rockets ignite, propel it to speeds required to operate its ramjet engine.

Q-5 is detected as "enemy" by ground radar (B), and its speed, altitude, and course are fed into fire-control computer of Nike battery.

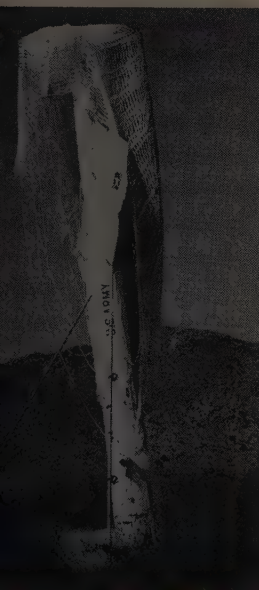
Missiles fired at Q-5 are like those used in wartime—but lack high explosive warheads. Nike missile (C) scores "hit" on Q-5's electronic image.





Above: Entering oval flight pattern, Q-5 attains speeds over 1500 mph. Second ground radar (D) and missile-launching battery (E) practice their marksmanship until Q-5 *Kingfisher's* fuel supply is exhausted.

Left: Landing on its nose-spike in a remote, uninhabited area, after floating down by parachute (F), the Q-5 is recovered by U.S. Army ground crews—to be refueled and refitted for future flights.



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RAMJET PROPULSION TESTING

IN A SQUEEZE?



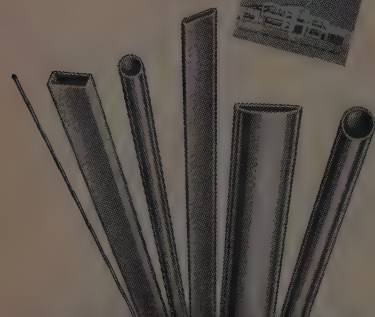
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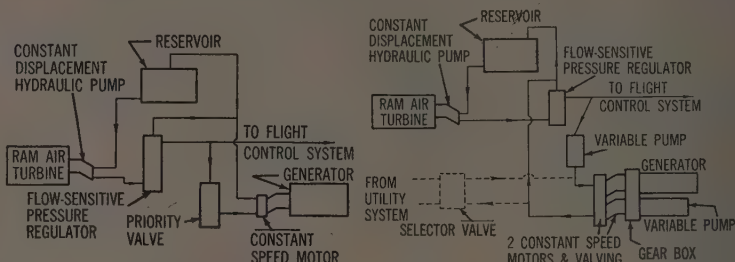


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Space/Aero Engineering

Accessory Systems



BASIC emergency hydraulic system (left) with generator for emergency electric power. This system can also power the aircraft utility system to operate flaps, landing gears, etc. Right: second constant speed motor (with gear box), which reduces power losses when the generator operates at a low load; extra variable pump to power the utility system; and selector valve for generator operation from the utility system have been added to the basic emergency system.

Ram air turbines meet aircraft emergency power needs

On high performance aircraft, air ram turbines will do the best job of supplying emergency power to hydraulic flight control systems, this article argues. In addition, electric generators for emergency operation can be included with such turbines.

**by J. M. Dutton and
D. C. Connett**

Application Engineer & Development
Engineering Section Chief, Aero Hy-
draulics Div., Vickers Inc.*

NORMALLY, engine-driven hydraulic pumps provide the power for operating an aircraft's flight control system. But what happens if there's a flame-out or some other engine failure? Designers can provide the necessary emergency hydraulic power through

the use of ram air turbines.

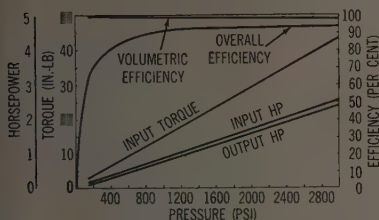
Such a turbine has an endless supply of power. It is more flexible than a battery or some other emergency power source. Finally, it has a big weight advantage.

The power requirement for the most critical control phase governs the size of the emergency ram air turbine. This phase usually consists of approach and flare, which call for a large hydraulic flow. However, the necessary hydraulic pressure is relatively low, because of the low landing airspeeds.

The ram air turbine's mechanical output usually is converted into hydraulic power by a hydraulic pump with either fixed or variable displacement. If a fixed displacement type is used to provide full system pressure (usually 3000 psi) down to landing speed, the high torque will cause the turbine to stall unless a very large unit is used.

If a flow-sensitive pressure valve is added to the system, it will re-

* Aero Hydraulics Div., Vickers Inc. (Div. of Sperry Rand Corp.), Detroit 32, Mich.



NEED for highly efficient pumps in ram air turbine applications is shown by typical performance of Vickers fixed displacement pump for a flow of 1-7/16 gpm from 150 to 3000 psi. This pump has been used with several ram turbines.

duce pressure and torque to values that the turbine can deliver at any speed. The relief valve setting decreases as the inlet flow decreases.

When the pump tends to slow down the turbine as airspeed decreases, the valve senses the reduced hydraulic flow and lowers the system pressure as needed, thus actually controlling turbine speed during low speed flight. Flow not needed by the system is returned to the reservoir.

If there is an engine failure during high speed flight—in which case the ram air speed gives a surplus of power—the valve acts as a conventional fixed-setting relief type.

The widely used systems that include such pressure regulation (see *Diagram*) need highly efficient fixed displacement pumps producing a flow and a pressure that are direct functions of turbine or pump speed and required torque, respectively. Weight considerations are all-important—the designer must take into account not only the pump's own weight but also the pronounced effect of pump efficiency on overall package weight. In some ram turbine applications, every pound of turbine package weight adds 5-10 lb to the weight of the aircraft structure (which must absorb the high loads imposed when the turbine is dropped into the air stream).

In case of an engine failure, a source of electric power is needed

more on next page

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Where you need the strength of a solid rivet—in those impossible, blind installations—the new Cherry 3/32" Self-Plugging Rivet is the answer.

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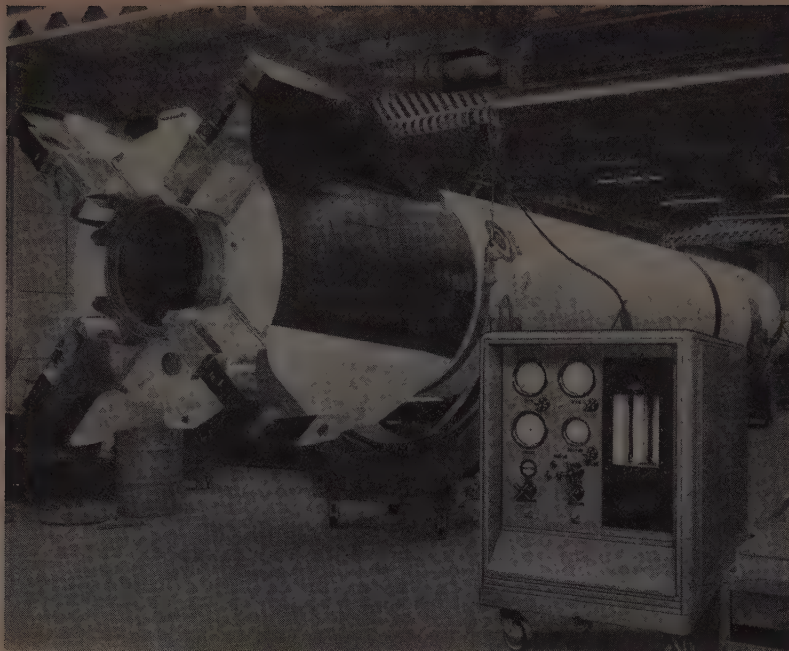
*Patents Issued and Pending

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In the manufacture and check-out of missiles, accurate testing verifies fulfillment of military specifications at Chrysler Corporation Missile Division. Pictured above is a Nankervis portable power package currently being used to test Jupiter and Redstone hydraulic systems.

Nankervis combines technical knowledge and experience to build a wide range of hydraulic test and ground support equipment for use throughout the missile industry. In the assembly of this equipment, Nankervis directs special attention toward contamination control, high-pressure sealing and other problems associated with missile testing.

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Portable Fluid Filtration Cart, Model 9545

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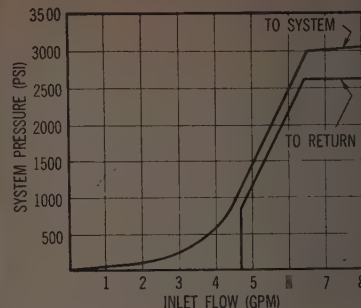
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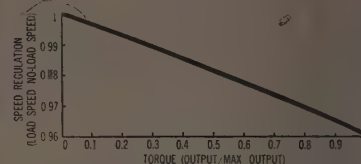
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RAM AIR TURBINES . . .



PERFORMANCE of flow-sensitive Vickers pressure regulator valve at full flow. With minor changes, the valve can be adapted to other, widely varying performance requirements.



PERFORMANCE of Vickers constant speed motor in ram air turbine applications. Speed is constant over the full load range within ± 2 per cent.

to drive instruments, radio, etc. This can be an electric generator that is added to the ram turbine system. Generally such a design is lighter than one using batteries or other power sources.

If the generator is fed directly from the turbine, its weight is added directly to that of the package. This means a disproportionate increase in structural weight. Moreover, if close frequency ac power is needed, the turbine speed must be controlled very accurately under widely varying conditions. Finally, a heavy electric load (such as a short circuit) could overload and stall the turbine. To prevent this, the turbine must be made oversize.

All these troubles can be avoided if the generator is driven by a constant speed hydraulic motor (see *Diagram*). This widely used arrangement saves a great deal of structural weight, since neither generator nor motor is part of the turbine package.

Also, the turbine control and the pressure regulator are not competing for the task of regulating the ac frequency. A priority valve makes sure the flight control system will always have priority on the flow delivered by the pump.

A second constant speed motor and a gear box can be added to

more on page 101

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SPACE/AERONAUTICS

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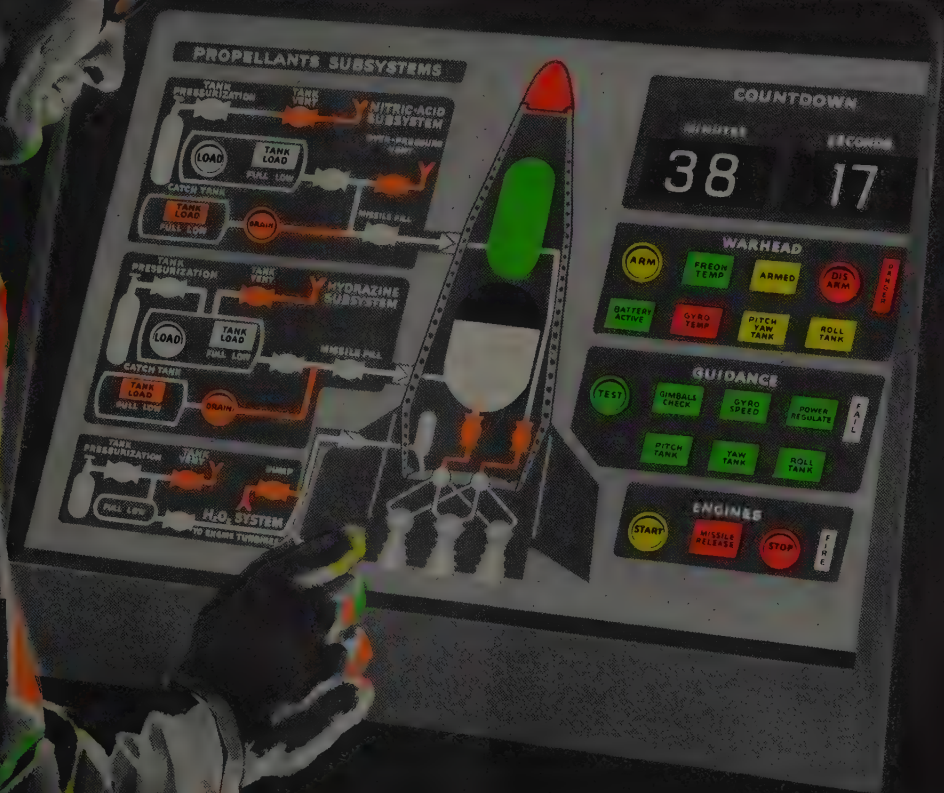
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the **astromatic** panel concept

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Study the following specifications with your project in mind . . .

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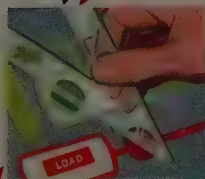
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EASY TO ALTER ... During prototyping legend and schematic diagramming can be easily changed to visualize any new findings. Components under panel may be re-located.

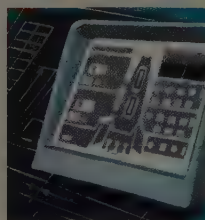
VERSATILITY OF DESIGN ... The module concept of construction makes the Astromatic panel technique extremely versatile. **WHATEVER ACTION YOU DESIRE TO VISUALIZE, ASTROMATIC CAN SUBMIT A PANEL DESIGN TO SURPASS YOUR EXPECTATIONS.**



100% FLUSH PANEL ... Eliminates protruding hardware... unless specified by human engineering requirements. Switching functions may be recessed, flush, or over-flush.



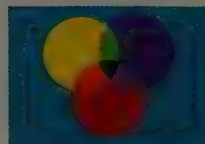
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4218 W. Lake Street, Chicago 24, Illinois

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☐ Please count me in on any Symposium held in my area.

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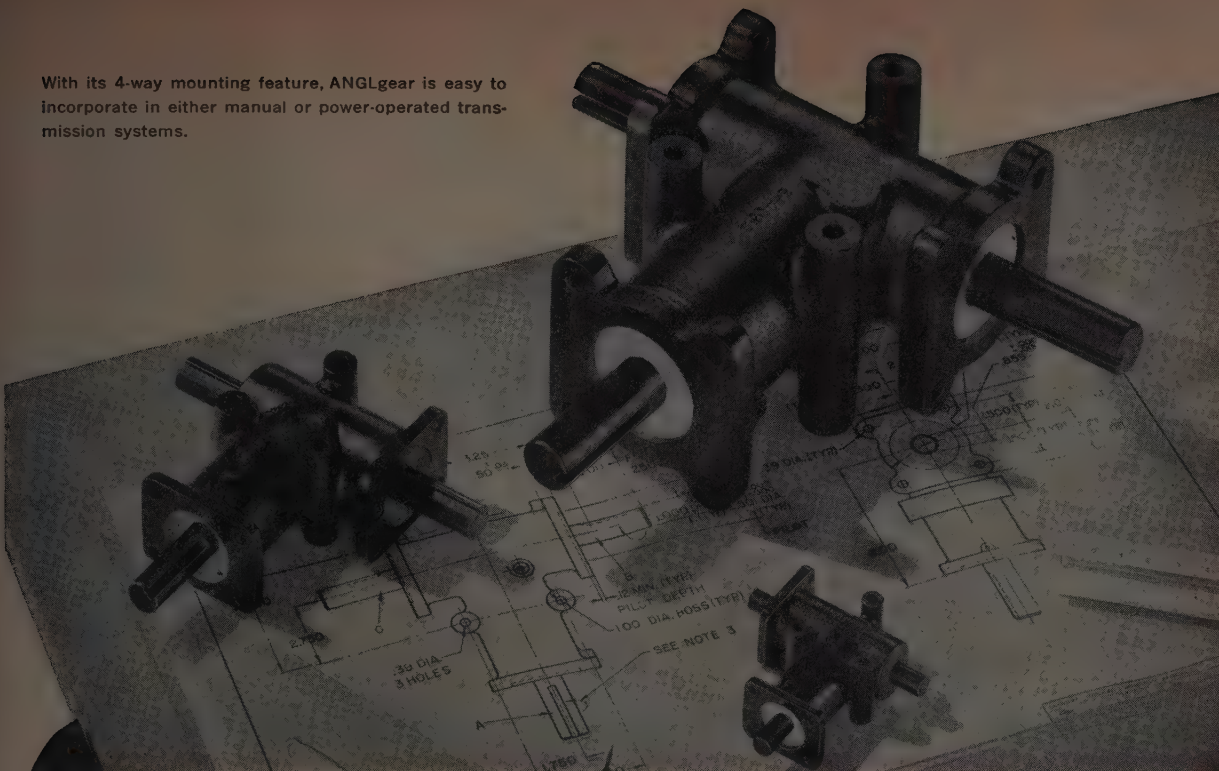
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mission systems; easy to install. With its precision gearing, it provides smooth, positive drive, free from backlash or slippage problems. Completely enclosed and permanently lubricated, it requires little or no maintenance. Furthermore, ANGLgear invariably costs less than other types of right-angle drives.

NEW CATALOG AA-58

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ANGLgear is available from stock in the types and sizes listed in the table below. Special sizes, special gear ratios, etc., can also be furnished to your requirements. Write for further information.

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AR-300-2	2-way	2:1	1/5	1800	250	3/8	.5
AR-310	3-way	1:1	1/3	1800	250	3/8	.5
AR-310-2	3-way	2:1	1/5	1800	250	3/8	.5
AR-320	2-way	1:1	1	1800	1000	5/8	2.2
AR-320-2	2-way	2:1	3/5	1800	1000	5/8	2.2
AR-330	3-way	1:1	1	1800	1000	5/8	2.4
AR-330-2	3-way	2:1	3/5	1800	1000	5/8	2.4
AR-333	2-way	1:1	2-1/4	1200	1500	3/4	8.7
AR-333-2	2-way	2:1	2-1/4	1200	1500	3/4	8.7
AR-335	3-way	1:1	2-1/4	1200	1500	3/4	9.0
AR-335-2	3-way	2:1	2-1/4	1200	1500	3/4	9.0

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New



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102

RAM AIR TURBINE



ASSEMBLY of two constant speed motors and gear box, made by Vickers, is used for ram air turbine of a Century series fighter.



VARIABLE displacement pump with controls for limiting turbine torque can be used with ram air turbines.

reduce power losses when the generator operates at half its rated load or less. One motor idles until the load exceeds half the rated capacity. Then it comes into operation automatically to share the load.

A small variable delivery hydraulic pump (driven from the gear box) can be added, too. It serves as a power source for the aircraft's utility system. This system's functions cause only low order power drains.

In deciding on turbine and pump sizes, we must consider that often no electric power is needed when airspeed is lowest. This means all the power output of the turbine can go to the control surfaces, where it is needed. If turbine and pump sizes are based on this condition, there will be enough power to supply both flight control and electric systems at higher airspeeds.

Valve used for alternate generator drive

A selector valve can be added to provide emergency electric power even when the ram turbine is not dropped into the airstream (see Diagram). When this valve is actuated, a flow is provided from the normal utility system to drive the constant speed motor and the electric generator.

If the mechanical output of the ram turbine is converted by a variable displacement pump, the flow-sensitive pressure regulator valve can't be used. Nor can the standard pressure-compensated pump be used without severe weight penalties unless the pump control system is modified.

Modification of the pressure-compensated pump control system can insure that the pump's torque

demand from the turbine will not exceed what the turbine can deliver without stalling during both normal operation and starting. This arrangement retains the full high pressure capabilities of the pump at any flow rate as well as the low system heat rejection during periods of low flow operation.

For any airspeed, the ram turbine can deliver varying amounts of torque, depending on turbine speed and governor setting. If the turbine is used to drive a hydraulic pump, the turbine speed will be further influenced by the hydraulic pump load. So the system load is independent of turbine and pump but has a definite effect on the operation of both these units.

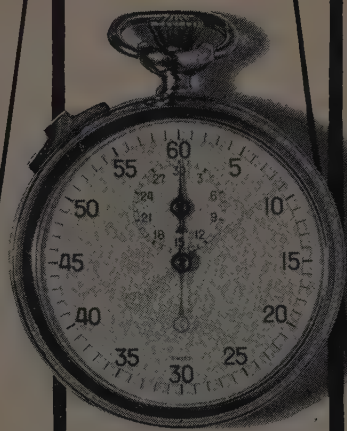
Therefore, the designer who wants to combine a variable hydraulic pump with an air turbine drive must consider the following:

- During starting, (1) the pump must demand from the turbine a torque less than the steady state torque available at any turbine speed; (2) it must be able to limit its torque demand in proportion to turbine speed regardless of the system loads imposed on it; and (3) if the system flow requirement at any speed is low, the pump should deliver full system pressure, provided the combination of flow and pressure does not cause the pump torque demand to exceed the turbine requirements for acceleration.

- In normal operation, the tur-

more on page 104

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SPACE/AERONAUTICS



Lino-Writ 4...fastest to use, fastest to process

Lino-Writ 4 is the *fastest, toughest, thinnest* paper you can use. Now with Du Pont's new low-odor Rapid Processing Chemicals Kit, it offers the additional advantages of fastest processing without sacrificing fine detail.

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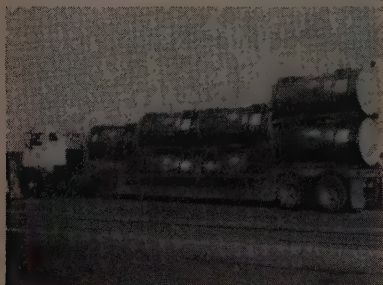
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*cut return shipment
space 1/2 ...*



End sections reverse and telescope into center section for return shipment.

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Harco Containers with integral Harco stores trailer can be return-shipped in 1/2 the space required for conventional containers.



Three steps of loading in-flight refueling stores into Harco Container; after unloading, Harco trailers are returned to container for re-use.

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REFUELING STORES CONTAINER APPROVED**

by BuAer, cuts 60% of weight, speeds loading and unloading of stores through unique Vee-band fastening of end sections to center section.



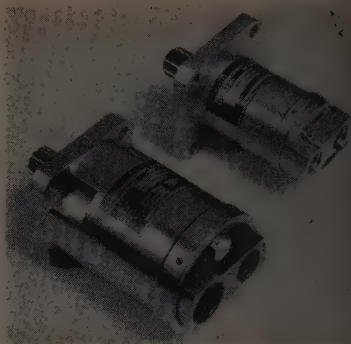
write for literature and quotations on your container and ground handling equipment requirements.

Harco Containers

A DIVISION OF HARBOR BOAT BUILDING CO.
258 CANNERY STREET, TERMINAL ISLAND, CALIFORNIA

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RAM AIR TURBINE . . .



MINIATURIZED hydraulic pumps should also be considered for ram air turbine applications. Respective data for these Vickers pumps PFM-3909 (left) and -3906 (right) are: theoretical displacement at 1500 rpm, 1.25 and 0.32 gpm; weight, 1.75 and 0.75 lb; top speed, 7800 and 12,000 rpm. Under certain conditions, top speeds can be increased appreciably.

bine torque should be enough to operate the pump regardless of the flow rates and pressures imposed on the turbine by the system. The pump will perform as a standard pressure-compensated type. It will supply a variable flow rate compatible with producing a fixed system pressure up to the full flow capacity of the pump.

• When operation is characterized by limiting pump torque requirements, the full flow capabilities of the pump are reduced without further sacrifice in pump operation. The pump can continue to operate as a pressure-compensated type but is limited to a lower displacement that depends on turbine speed.

We can see that a variable displacement pump can produce full pressure for all phases of operation. It will not stall the turbine during starting or at low or high turbine torque. Also, it supplies only the flow needed by the system. Heat rejection is minimized and system efficiency is at a maximum. This pump can be used in any of the systems discussed here.

System requirements and turbine capabilities determine which type of pump should be used in a given design. Variable delivery pumps are slightly larger and heavier than constant displacement type, but performance requirements may warrant some sacrifice of size and weight. Write in No. 53 on Reader-Service Card for more data.—End



NEW TAKE-OFF MONITOR GIVES CRITICAL PERFORMANCE DATA

Sperry indicator aids pilot's Go, No-Go decision



With the new Sperry Take-Off Monitor, the pilot gets an *instantaneous and continuous* indication of the performance of his aircraft from the moment take-off begins.

This simple and extremely accurate system is based on aircraft acceleration. Data is *computed instantly, presented*

← **ONLY ONE PRE-TAKE-OFF ADJUSTMENT** is required in Sperry's Take-Off Monitor. With the knob on lower right pilot sets acceleration index and gross weight of aircraft. So long as pointer remains in "safe" area, pilot knows his aircraft is performing as expected. A simple "push to test" feature is provided to indicate proper system operation prior to take-off run. In addition, a warning flag monitors system power.

instantly. Without having to make allowances for wind, the pilot knows at all times whether the take-off should be continued.

Consisting of two small units, an integrally-lighted indicator and computer, this system can be easily retrofitted into existing aircraft. With simple computer adjustment, it is suitable for either jet or turbo-prop aircraft.

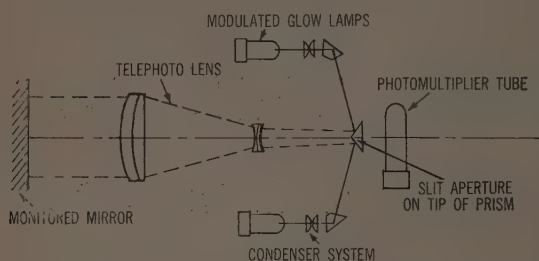
AERONAUTICAL EQUIPMENT DIVISION

SPERRY GYROSCOPE COMPANY
Great Neck, New York

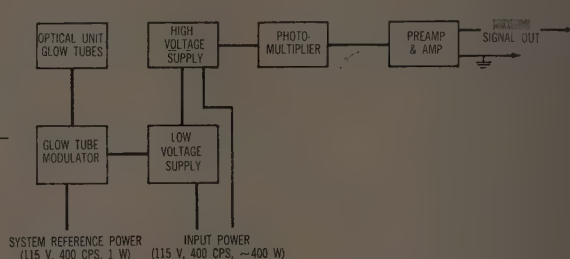
DIVISION OF SPERRY RAND CORPORATION

Write in No. 151 on Reader Service Card at Start of Product Review Section

Ground Support



BASIC elements of optical system in Perkin-Elmer 169 azimuth alignment theodolite. Mirror surfaces struck by the beams from the glow lamps are aluminized on both sides.



BASIC elements of electronic system used with 169 alignment theodolite. Voltage and phase of error signal depend on the mirror deviation angle. Error signals keep missile on target heading.

Theodolites automatically align operational Jupiter

Only an optical system has the precision needed for the azimuth alignment of long range inertial guidance systems. Here is a report on the theodolite setup that does this job on the operational Jupiter IRBM. The same basic system could be used with other ballistic missiles and with some spacecraft.

by Don Karshan

THE ACCURACY of a long range ballistic missile depends very much on how accurately it is aligned in azimuth on the launching pad. If the stable platform in an IRBM, for instance, is misaligned by a few seconds of arc, the resulting impact error at the target may be measured in tenths of a mile.

Actually, the azimuth alignment of a missile is a target selection process. A stable platform is designed to maintain a space-fixed frame of reference during flight. Therefore, if you physically rotate

the missile and its stable platform in azimuth on the launching pad, you line up this reference with the azimuth plane in which the target lies. Once launched, the missile then follows this "zero" reference to the target.

Optical-electronic alignment systems provide the accuracy needed in establishing the target (hence missile and stable platform) reference plane—within tolerances of 0.000011 in. An azimuth alignment theodolite is used to maintain the missile azimuth. It keeps the reflections from a mirror mounted on the stable platform under continuous observation. Any rotational discrepancies generate error signals. Via a closed loop servo system, these are applied as corrective signals to the drive elements of the monitored equipment.

The monitoring optical system consist of two light sources, a telephoto objective lens, a beam-dividing V-prism, and a photomultiplier tube. The two glow-discharge-lamp light sources are electronically modulated at 400 cycles in phase opposition. Separate condenser systems transmit the light from the lamps to a prismatic mirror that is mounted on the missile stable platform and reflects

the beams along the optical axis of the objective lens.

The reflected light is picked up as a signal. If the mirror is perfectly "squared on" with the optical axis of the system, the light will re-enter the objective, fall on the opposite side of the prism, and be lost in the source system.

If the monitored mirror is "off" in azimuth by even the slightest amount, the returning beams will not be centered on the optical axis. Instead, they will pass through a slit (ground and polished on the apex of the prism) and strike the photomultiplier. This produces an error signal whose phase relationship with the reference voltage is a measure of the direction and magnitude of the azimuth deviation.

These error signals are fed to the stable platform to drive the platform back to conformity with the beam of light and so the correct azimuth heading. The entire closed loop therefore is automatically self-correcting.

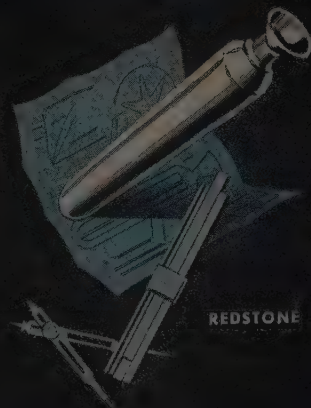
The error signals continuously counteract any tendency of the platform to move away from an established target heading. The platform azimuth is controlled automatically within very small limits and over long periods right up to the instant of launch. (Error signals generated by the theodolite may also be recorded to obtain long-term data for corrective adjustments.)

With today's theodolites, angular

more on page 108



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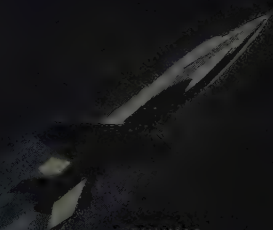
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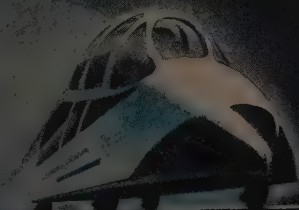
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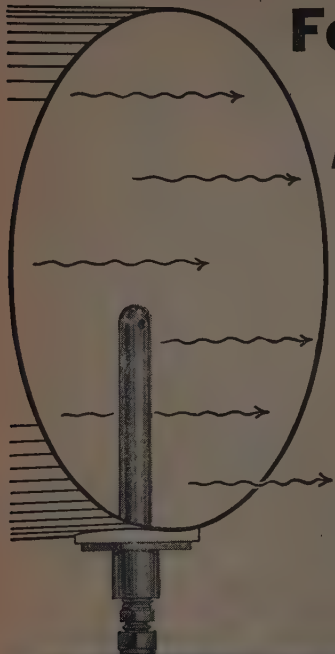
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Write For EDS-36-A

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SADDLE BROOK, NEW JERSEY

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THEODOLITES



JUPITER nose cone showing window slit for prism mirror mounted on stable platform.

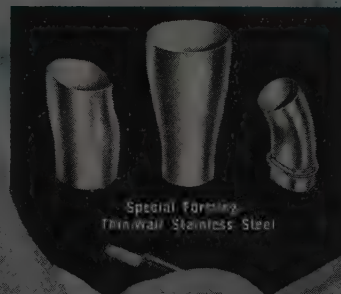
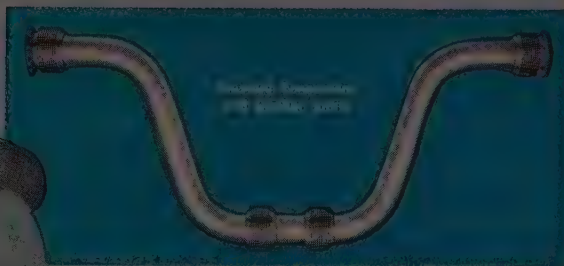
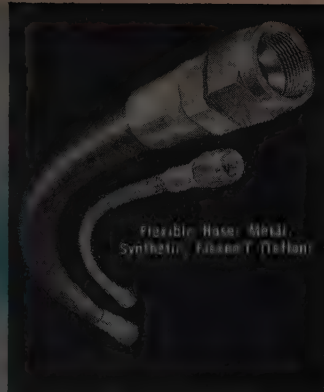


INTERMEDIATE RANGE theodolite setup showing Jupiter IRBM about 400 feet away. Lens is aimed at stable platform prism for primary target alignment.

deviation can be measured even in the presence of missile sway or inclination. When a missile is aligned upright on the launching pad, its nose section (in which the stable platform is located) is susceptible to a sway of greater magnitude than the monitored prism width. The Jupiter's long range theodolite therefore includes a sway compensation system to keep the prism from being moved even partially out of the theodolite's beam.

Two theodolite systems made by The Perkin-Elmer Corp., Main Ave., Norwalk, Conn., are used

more on page 110



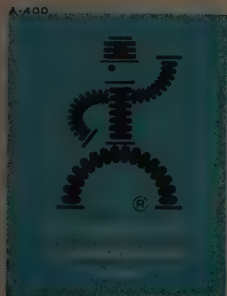
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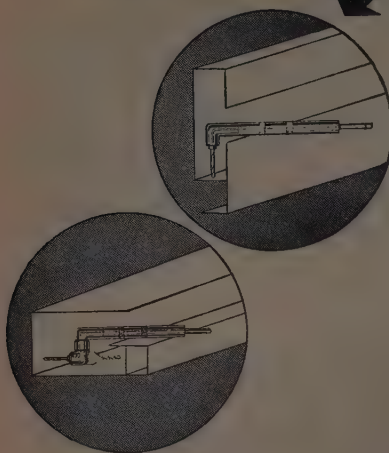
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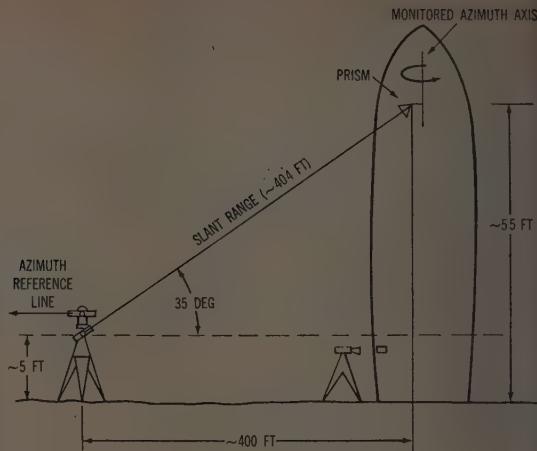
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THEODOLITES . . .

OPERATIONAL arrangement of long and short range theodolites used for azimuth alignment of Jupiter IRBM.



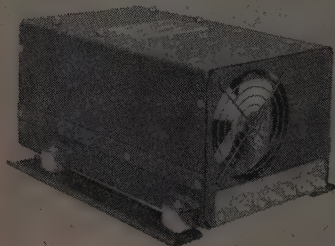
in the operational alignment of the Jupiter. One is the intermediate range Model 523 for primary aiming, located about 400 ft from the base of the missile. The other is the auxiliary short range Model 169, stationed 3-4 ft from the missile.

The intermediate theodolite is

sighted on the prism mirror on the stable platform—part of the guidance system made by Ford Instrument—in the nose section. The short range unit is sighted on an auxiliary prism attached to the launching ring on which the Jupiter missile is positioned.

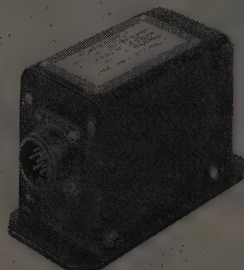
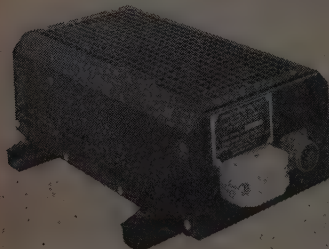
The auxiliary prism (which re-

more on next page



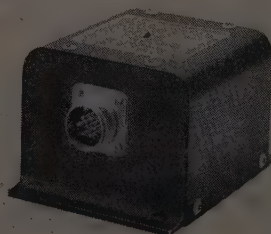
SELENIUM TR UNIT
shock mounted model 28V100-5

SILICON TR UNIT
convection cooled model 28VS100C



DC-DC CONVERTER
dual output model 75D2D50

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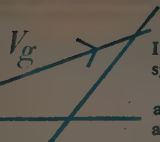
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Ground Speed & Drift Angle
Any Time, Anywhere, Any Weather



One look and the pilot KNOWS. In a glance he reads actual ground speed and drift angle.

This vital data, never before available, is displayed on the flight panel automatically and continuously.

The dials "read" the key unit in GPL's revolutionary Doppler auto-navigation systems. Other phenomenal units in these systems tell where

you are and how to get where you're going. The systems operate entirely without ground aid or celestial fixes, have proved themselves globally in millions of operational miles.

GPL's auto-navigators are the result of GPL's harnessing of Doppler-effect to air navigation—an achievement comparable in magnitude to the breaking of the sound barrier.



RADAN joins the jet crew

Today's military and jet-liner crews have an added member—an 80-pound navigator named RADAN!*

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RADAN navigators are members of the famed GPL family of Doppler systems—developed in conjunction with the USAF (WADC). GPL auto-navigators have literally revolutionized flight. They are the only

self-contained systems in the world proved over millions of operational miles.

Recent release of RADAN Systems for civilian use now makes their benefits available to everyone. RADAN saves time and precious fuel for the air lines, provides a priceless margin of safety for all.



GENERAL PRECISION LABORATORY INCORPORATED, Pleasantville, N. Y.

*Trademark

ENGINEERS—GPL achievements have opened up some unusual research and development opportunities. Send resumé to Personnel Manager.

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KEARFOTT PRECISION RESOLVERS FOR EVERY SYSTEM APPLICATION



Kearfott has available a complete line of precision resolvers for every system application. Computing resolvers range in functional accuracy from .05% to .005%, in bridge accuracy from 3 minutes to 20 seconds of arc and in size from 11 to 25. Non-compensated resolvers range from 5 minutes to 20

seconds of arc in accuracy, from 8 to 25 in size. All Kearfott resolvers feature stainless housing, shafts and bearings and corrosion-resistant lamination materials for maximum environmental resistance. Optional designs available for operation at 200°C and in environment of 2000 cps vibration at 30 g's.

Computing Resolvers

Available with integral compensating windings. Can be provided with trimming networks to match existing isolation amplifiers or Kearfott-designed transistorized amplifiers.

Size 11

For applications where size and good functional accuracy are of paramount importance. Functional accuracy as good as .05% and bridge errors of 3 minutes of arc are in production.

Size 15

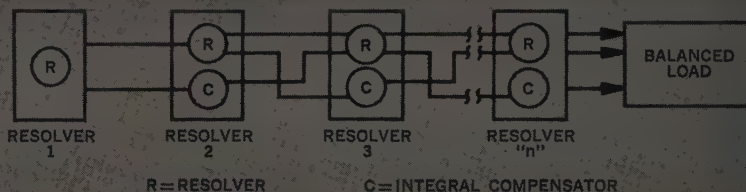
A 2:1 improvement in functional accuracy and bridge error obtained in this configuration. Unit tabulated is the direct equivalent of standard Navy BuOrd Mark 4 Mod 3 and contains necessary trimming network for standard buffer amplifiers. Transformation ratio is $1.000 \pm .0001$, phase shift $0^\circ \pm 1$ minute. Functional accuracy of .025% and bridge error of 1.5 minutes of arc are standard.

Size 25

For applications demanding the highest order of accuracy. Close attention has been paid to design parameters.

Size 18

A special resolver which permits a unique cascading of these units without the necessity for buffer amplifiers. Typical application is illustrated in following cascade:



COMPENSATED RESOLVERS FOR PRECISE COMPUTER APPLICATIONS

SIZE	11		15	18	25
PART NUMBER	R980-01	R980-41	T980-51	V980-004	425506-1
Excitation Volts—(Max.)	60	60	26	26	25
Frequency—(cps)	400	400	400	400	400
Primary Impedance	629 + j2510	450 + j2200	220 + j1000	3000 + j (0 ± 40)	1630 / 78.5°
Secondary Impedance	695 + j2750	500 + j2300	240 + j1100	3000 + j (0 ± 40)	1620 / 80°
Transformation Ratio (Primary to Secondary)	.980	.980	.980	.775	.980
Transformation Ratio (Compensator to Rotor)	.985	.985	.950	.775	.985
Phase Shift (Lead)	8.5°	7.5°	8.5°	0° ± 10'	1°
Fundamental Null (MV)	15	15	8	15	15
Bridge Error From E.Z. (Max.)	7 mins.	5 mins.	3 mins.	3 mins.	20 Seconds
Primary	Stator	Stator	Stator	Stator	Stator

Non-Compensated Resolvers

Basically for application in precise data transmission systems. These synchro resolvers permit system designer to achieve system errors of better than 1 minute of arc without using 2-speed servos and elaborate electronics. By proper impedance matches up to 64 resolver control transformers can also operate from one resolver transmitter.

Size 11

Where size is important. These units have a maximum unit error of 3 minutes of arc.

Size 25

Where highest accuracy is required. These units have a maximum error as low as 20 seconds of arc.

NON-COMPENSATED RESOLVERS FOR PRECISE DATA TRANSMISSION

	SIZE 11			SIZE 25		
Type Resolver	Transmitter	Differential	Control Transformer	Transmitter	Differential	Control Transformer
Part Number	R982-004	R982-011	R982-012	Z5161-001	Z5191-001	Z5151-003
Excitation Volts (Max.)	26	11.8	11.8	115	90	90
Frequency (cps)	400	400	400	400	400	400
Primary Impedance	$170 / 77^\circ$	$850 / 80^\circ$	$2000 / 80^\circ$	$400 / 80^\circ$	$800 / 80^\circ$	$8500 / 80^\circ$
Secondary Impedance	$42 / 80.5^\circ$	$1000 / 79^\circ$	$8000 / 76^\circ$	$260 / 80^\circ$	$900 / 80^\circ$	$14000 / 80^\circ$
Transformation Ratio	.454	1.000	1.906	.7826	1.000	1.278
Max. Error from E.Z.	3 mins.	3 mins.	3 mins.	20 seconds	20 seconds	20 seconds
Primary	Rotor	Stator	Stator	Rotor	Stator	Stator

Write for complete data.

KEARFOTT COMPANY, INC., Little Falls, N. J.

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Kearfott



Write in No. 159 on Reader Service Card at start of Product Review Section

THEODOLITES . . .



SHORT RANGE theodolite setup for Jupiter showing lens aimed at launching rig's auxiliary prism which has the same heading as the stable platform prism in the nose cone. A second auxiliary prism at the right represents the angle of secondary targets.

flects the azimuth position of the missile) has the same heading as the one on the stable platform. With everything properly aligned, both prisms should point out the angle of the missile's primary target.

There is also a second auxiliary monitoring prism attached to the launching ring at the base of the missile on which the short range theodolite can also be sighted. The position of this second, adjustable prism represents the azimuth angle of secondary target points.

The basic function of the short range theodolite is to back up the intermediate setup. It takes over the alignment adjustment in special cases—such as when poor weather might interfere with or distort the beam path to the nose section. Write in No. 57 on Reader-Service Card for more information.—End

CLOSEUP of intermediate range theodolite.



TRIGGER



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SEQUENCE



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PRESSURE ACTUATED



PRESSURE RELIEF



new *Robertshaw* AIRCRAFT VALVES with "wear-proof" CAPTIVE SEAL®

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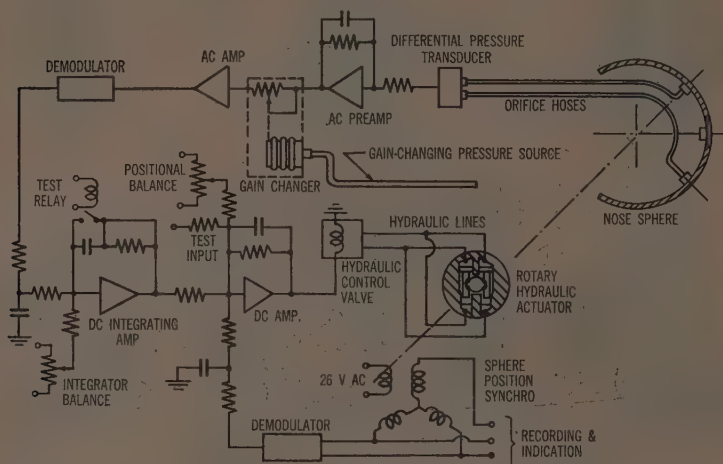


Robertshaw-Fulton

CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • Milford, Conn.

Write in No. 160 on Reader Service Card at Start of Product Review Section



FUNCTIONAL diagram of servo system mechanization shows both angle-of-attack and sideslip-angle loops.

Mach 1-10 sensor for re-entry angles and pressure

When a requirement arose for a Mach 1-10 air flow direction and pitot pressure sensing system, Nortronics engineers literally picked up the ball and designed a spherical servo sensor that promises an important advance in the state of the art.

UNDER contract, to NACA, Nortronics Div., Northrop Aircraft, Inc., Hawthorne, Calif., has developed a unique spherical air flow direction and pitot pressure for Mach 1-10. Called the "Q-ball," the compact, integrated system measures angle of attack, sideslip angle, and dynamic pressure at extremes of temperature and atmosphere. It is designed for aircraft and missiles that climb to very high altitudes and re-enter the atmosphere after a ballistic trajectory.

The *Diagram*, applying to both angle-of-attack and angle-of-side-slip loops, shows the system is mechanized with an inner positional servo loop controlled by an outer, unity-feedback, differential-pressure, high gain loop. By using these two loops, Nortronics gets the following characteristics:

- Null shift with temperature (in the electrohydraulic control valve in the positional loop) cannot affect the null stability of the outer control loop.

- Gain variations in the electrohydraulic valve of the positional loop, caused as fluid viscosity changes with temperature, are seen by the outer control loop as changes in the dynamic term of the transfer function, rather than as changes in the gain of the outer open loop.

- Pre-flight checkout is simplified for the entire positional loop can remain operational in the absence of simulated or actual dynamic pressure.

Both loops are completely



Q-BALL system measures angle of attack, sideslip angle, and dynamic pressure during re-entry.

transistorized. To minimize drift in the outer control loop, the 400-cps output signal of the differential pressure transducer is amplified in both the preamp and the gain-changing amplifier. An outer open loop gain change of 167:1, which corresponds to changes in dynamic pressure of 15-2500 psf, is accomplished in the gain changer amplifier network.

Direct actuator coupling eliminates backlash

This network resistance change is made a function of dynamic pressure by means of a precise pressure transducer and an instrument servo that gain-compensate both angle-of-attack and angle-of-side-slip control loops. Nortronics avoided gimbaling and conventional actuator linkages—with their usual friction problems—by using rotary actuators that are coaxial with the sphere's axes of rotation. Direct coupling to the sphere completely eliminates backlash.

The sphere's orifice layout was designed to give Q-compensation over a wide range of Mach number. A control and a displaced orifice sense the sphere pressure gradient, which is used to operate the compensation transducer. The Q-ball project reportedly is in its final phase. Complete sensor systems are already being tested. The static sensitivity and dynamic re-

more on page 116

LIVE

WIRE

New design in Sigma hand welding torches

Here is a new, lightweight torch—only 16 ounces—for manually welding light-gage steels. Sigma ST-2 welds in all positions with no change in control or current settings. Welds .030- to .100-in. sheet, using low-voltage short-arc technique with .020- and .030-in. hard-drawn wire. For 200 amp continuous service, a-c or d-c.

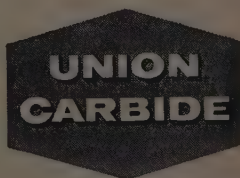
Balanced design makes handling easy. Service lines enter through rear of handle—a convenience in cramped quarters. Start-stop switch on handle, easy to reach. Nozzle has a 60° curve for maximum weld visibility.

Sigma ST-2 makes high-quality welds at high speed. Seams require no cleaning . . . dis-

tortion is at a minimum. Inert gas shielding is economical. Low flow rate—only 10 cu. ft. or less per hour—means even more savings.

Call your nearest LINDE office today for a demonstration of this new Sigma ST-2 torch! Or write Dept. J-2, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE-MARK

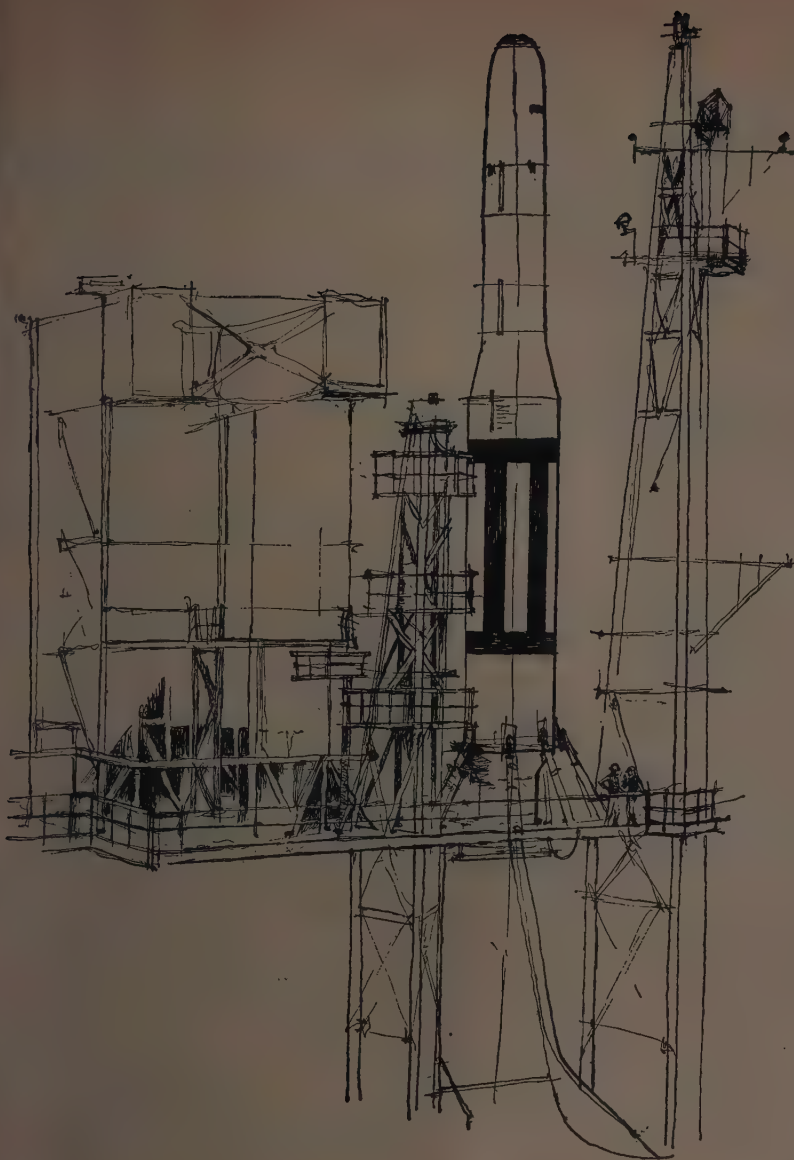


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There is nothing else like this under the sun. It is the Martin-Denver facility, birthplace of the Air Force TITAN. It is also this country's most advanced and fully integrated big-missile development center. Here, our most formidable weapon systems of tomorrow are being designed, built and tested—from the smallest component to the total system—within a single 7,000 acre complex. Every top military and scientific expert who has seen Martin-Denver from *within*, considers it one of our most valuable national resources.





RE-ENTRY SENSOR . . .

Q-Ball Sensor Performance

Positional accuracy ± 0.25 deg (nominal)

System threshold 0.001 psi (max)

Frequency response 3 db @ 7 cps

Velocity 240 deg/sec*

Velocity error 1 deg @ 60 deg/sec

Q-compensation gain-compensated for dynamic pressure range of 15-2500 psf

Stagnation temp 4000 deg F (max)

Altitude sea level to 300,000 ft**

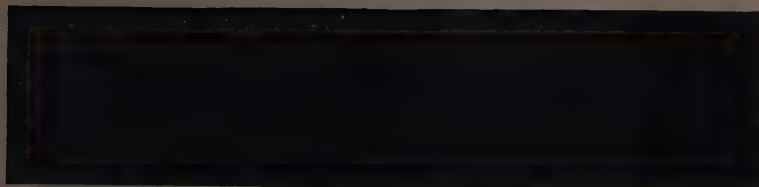
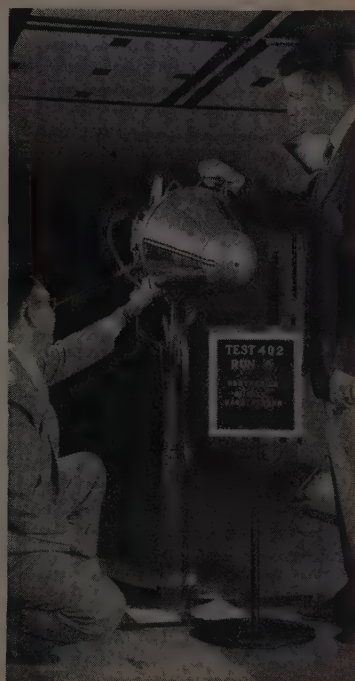
Mach number 1-10**

*Except at extremely high Q saturation.

**Limited to Q of 2.5-2500 psf and stagnation temperature of 4000 deg F.

sponse the device has shown under test, Nortronics claims, indicate that it will go a long way toward better angle-of-attack and sideslip measurement in extreme environments.—BK

PROTOTYPE of Q-ball sensor is installed for test in Northrop wind tunnel.





Bolt cuts drive shaft

SHORTLY after takeoff, the aircraft's wing flaps failed to function properly. An emergency landing had to be made. To keep from overshooting the runway, the pilot had to brake so hard that a tire blew and the landing gear was damaged.

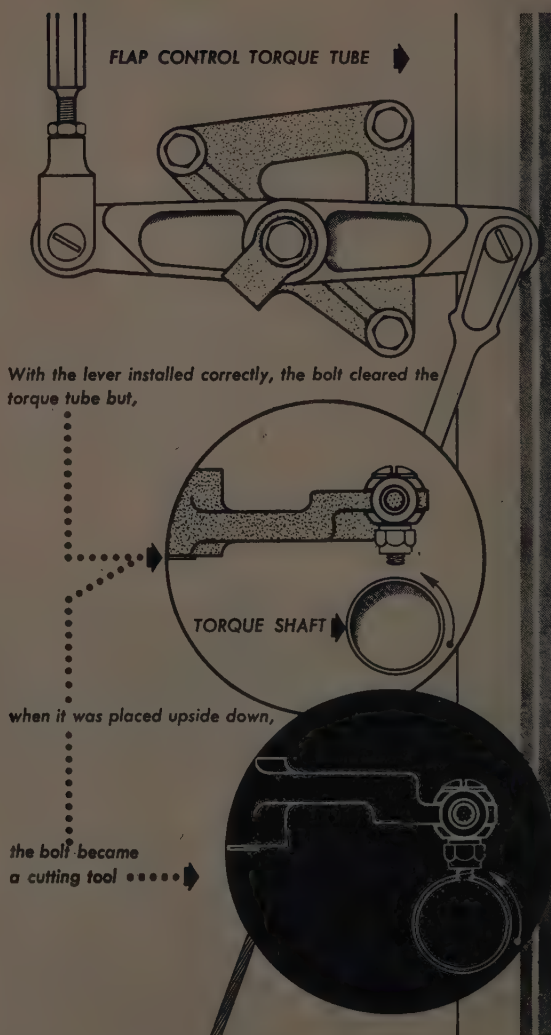
One of the flap drive shafts had broken, reports **Flight Safety Foundation, Inc., 468 Fourth Avenue, New York 16, N. Y.**, and caused the malfunction. A lever of another control system had been replaced during overhaul, and the new lever had been installed in the reverse of its proper position. With the lever turned upside down, a cable-connecting bolt in it came into contact with a revolving torque tube and cut it in two.

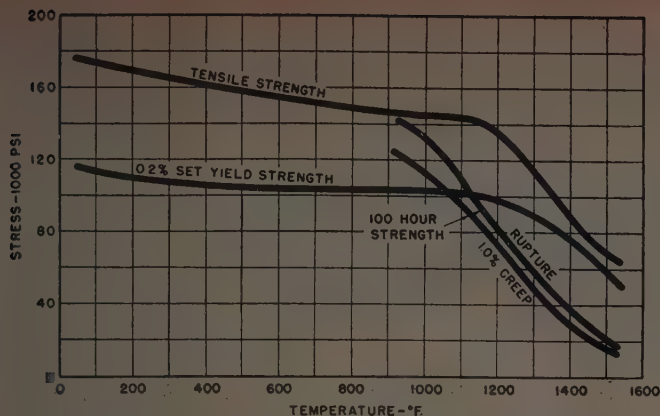
Correctly installed, the bolt clears the tube.

THE HAZARD

The flap control system in this aircraft, FSF engineers point out, was designed asymmetrically as a fail safety measure. Had this not been done, the flap on one side would have stopped while the opposite flap continued its travel and would have caused a sudden loss of control.

The lever wasn't noticeably asymmetrical. This made the wrong installation easy—a possibility, says FSF, that was overlooked when the lever was designed. (Murphy's Law: "If an aircraft part can be installed incorrectly, someone will install it that way.")





Graph shows high tensile, creep and rupture strength Incoloy "901" provides at 1000°-1400°F.

New standard alloy... "super" alloy properties!

In the 1000°-1400°F range, Incoloy "901"* iron-nickel-chromium alloy has properties which match those of "super" alloys.

Its nominal composition is 40% nickel, 13% chromium, 2.40% titanium, 6.00% molybdenum. The balance: iron.

Incoloy "901" alloy was especially developed for rocket and gas turbine components. This alloy provides high tensile, creep and rupture strength (see graph), good oxidation resistance and favorable expansion characteristics at elevated temperatures.

Solution treatment extends time-to-rupture

In bar stock, time-to-rupture for a given stress and temperature can be extended by a high temperature solution treatment before aging. Sheet is best formed in the annealed condition and aged by a short time (2 hr) treatment at 1400°F.

Other new high temperature alloys developed by Inco

In addition to Incoloy "901", Inco has developed four other high temperature alloys which deserve attention in missile design. They are: Inconel "713 C"* nickel-chromium alloy, Inconel "700"* age-hardenable nickel-cobalt-chromium alloy and Inconel "702"* aluminum-containing nickel-chromium alloy. For basic data on all five, write to the address below.

*Registered trademark

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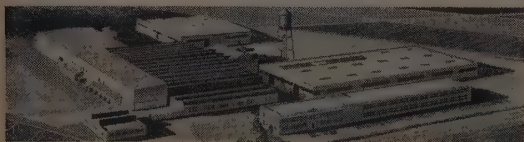
NAVY SELECTS RYAN C-W DOPPLER NAVIGATORS FOR MAJOR AIRCRAFT

Six major types of Navy aircraft will be equipped with Ryan continuous-wave Doppler navigation systems, the AN/APN-122 (V), under an initial \$20-million contract awarded by the Navy to Ryan's Electronics Division. Ryan's automatic, all-weather, self-contained navigators will be installed in the Navy's Lockheed Neptunes (P2V), Martin Marlin patrol planes (P5M), carrier-based Douglas Sky Warriors (A3D), and three types of Grumman aircraft.

Developed in cooperation with the Navy, these advanced electronic systems are the lightest, sim-

plest, most compact, and most reliable of their type. The new order, one of the largest of its kind, emphasizes Ryan's leadership in navigation and guidance systems.

With a solid backlog of this and other important contracts for RYANAV systems, the Ryan Electronics Division is growing even faster than this fastest growing industry. Personnel and facilities are being doubled, both in the new production plant at Torrance, Calif. and at the San Diego facility, where a modern new electronics research center is under construction.



New electronics production facility at Torrance (near Los Angeles).



New electronics research center at San Diego.

Ryan's rapid growth in electronics is creating new opportunities for engineers and technicians

RYAN BUILDS BETTER

ELECTRONICS DIVISION

Ryan Aeronautical Company, San Diego, California

space *aero* *Electronics*



Collins tracking antenna for space probes

synchros

in the popular Size 8 line

are now in production at Daystrom Transicoil.
The new size 8 Synchro Line includes high quality, top performance transmitters, control transformers, differentials, and repeaters. Frame size equal to BuOrd Size 8. Operation: 115V 400 cycles or 26V 400 cycles. Accuracies to $\pm 5'$ are available. Corrosion resistant construction throughout. Conforms to MIL-E-5272-A.

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Army Signal Corps engineers score with Score

PROJECT SCORE, despite its eclipse by Lunik, will go down as one of man's most significant firsts in electromagnetic communication. It gave the first hardware demonstration of the long discussed satellite radio relay.

Credit for Score's communications and control package goes to the Army Signal Corps engineers who ran the crash program and did much of the actual design work themselves.

COMM AND TRACKING package in the talking Atlas consisted of two 10-W FM transmitters (2.5 lb each) for voice, two 10-mw AM transmitters (0.75 lb each) for beacon, two FM receivers (10 oz each) for voice and control, two electronic control units (0.75 lb each, and a tape recorder and playback mechanism.

In-the-bird equipment was mostly of solid state design. Tubes were used in the outputs of the 10-W transmitters and in the receiver front ends.

Score tape recorder controlled by ground radio

VOICE TRANSMITTERS operated on 132.9 mc, with a deviation of 10-12 kc. (Ground-to-space frequency was not announced, but was in VHF region.)

The tape recorder was controlled by radio signals from ground. Signals could command record (tape had a four-minute capacity), playback, and erase.

BEACON FREQUENCIES of 109.97 and 109.4 mc were used to work with Minitrack tracking stations. Internal temperature was also sent down via the beacon signals.

Power for the entire package came from zinc-silver oxide-cadmium batteries with an expected life of 30 days. However the voice transmitter conked out after 13 days and the 109.97-mc beacon after one day.

Low Atlas rpm cut spin fade

SPIN FADE, a vexing problem in satellite communications—spinning of the vehicle and its antennas can cause gain variations of ± 20 db and a fluttering signal at the ground receiver—gave little trouble. Signal Corps engineers say that, because of its relatively large mass, the Atlas satellite rotates at only about one rpm.

TELEVISION from space will be a tough nut to

crack say Signal Corps engineers. Scintillation due to varying densities of the atmosphere will cause refractions. So the same signals will arrive by several path lengths, causing ghosts and poor pictures.

Power supplies, frequencies, miniaturization . . . three space comm posers

SIGNAL CORPS engineers rank power supplies, miniaturization, and proper choice of frequencies as major factors in space comm design. Collapsible solar cell sheets that are extended in space might solve the power supply problem. The idea is to get sufficient surface area in space to capture the sun's energy.

On frequencies, Signal Corps feels 250-300-mc area gives the best compromise between bending of lower frequencies and attenuation of the higher ones.

RUSSIANS ANNOUNCED the use of four frequencies on Lunik: 183.6, 199.93, 19.995, and 19.997 mc. The second reportedly was received by Signal Corps post at Deal, N. J., before it faded out at around 375,000 miles from earth.

HOW FAR can communications be maintained with present state of the art equipment? Rough calculations by Signal Corps engineers are that 10 W from 500,000 miles (assuming a normal attenuation of -136 dbm and 15 db gain at the ground antenna) would yield about a 0.1-uv signal. This is well within the sensitivity range of existing communications receivers.

At 1,000,000 miles, attenuation jumps to -143 dbm. This would give a -128 dbm signal level at the receiver, and is also well within the capabilities of today's average ground receivers (which will work down to -140 dbm).

Better tactical data system

AIRBORNE tactical data system made by Litton is designed to perform early warning and control function some 20-30 times more effectively than present systems. The equipment is based on Litton's most advanced airborne digital computer and display techniques. The self-contained, automatic system will cut interception time and virtually rule out human errors, claims Litton.

Features are automatic detection, automatic track-while-scan, "unusually reliable" separation of targets from video noise, and automatic direction of interceptor planes or missiles.

more on next page



In the works since '56, the system will be soon test flown aboard a Navy AEWC airplane.

INERTIAL SYSTEM for North American's X-15 manned space probe (see *Schematics*) measures velocity, altitude, position, and attitude relative to earth. Its stable table is kept normal to the geographic vertical. All accelerations due to kinematic velocities and changes in earth's mass attraction force are computed and inserted into the system.

The overall system designed by Sperry Gyro-scope, is divided into two groups—one in B-52 carrier aircraft, the other in the X-15 itself. Equipment in the B-52 supplies the computer in the X-15 with conditions prior to launch to align and stabilize the inertial platform (in the X-15).

Four axes of rotational freedom in the stabilizer

STABILIZER has four distinct axes of rotational freedom: roll, pitch, inner roll, and azimuth. The last three are mutually perpendicular. The outer roll axis is gimballed relative to the X-15's longitudinal axis and together with the inner roll axis to produce an angular displacement proportional to roll attitude. The redundant roll axis allows

unlimited maneuvering without any danger of gimbal lock or loss of verticality, says Sperry.

STABLE PLATFORM consists of three integrating floated gyros and three linear accelerometers. Gyro Characteristics: random drift, 0.05 deg/hr; mass imbalance, one deg/hr/g; ainsolasticity, 0.02 deg/hr/g²; reaction torque: one deg/hr; fixed drift, 0.1 deg/hr; angular momentum: 10⁵ gm-cm²/sec; weight, 0.48 lb; diameter, 1.75 in.; length, 2.75 in.; torquers, per cent; ± 0.25 per cent; max. temperature: 187 deg F.

The accelerometers, recently de-

veloped by Sperry consist of test mass, capacitive sensing element and force balance servoamp. Threshold is better than 10⁻³ g and accuracy, without recalibration, says Sperry, is on the order of 10⁻⁴ g. Other characteristics: linearity, ± 0.0003 g or 0.1 per cent whichever is greater; range, ± 10 g; weight, 1.5 lb; size, $\frac{3}{4} \times 2\frac{7}{8} \times 1\frac{3}{4}$ in.

Inertial system works over unlimited attitudes

SYSTEM will operate over unlimited aircraft roll, pitch, and yaw attitudes. Top rate in roll and pitch is 2500 deg/sec; in yaw, 4000 deg/sec. System will also operate in maximum aircraft accelerations of 1500 deg/sec² in roll and pitch and 1800 deg/sec² in yaw.

Warmup time is 15 minutes from a -65 deg F ambient. Top vertical accuracy under dynamic inputs is two minutes of arc.

The computer is a dc electromechanical analog type.

HIGH RESOLUTION airborne radar using beam-sharpening antenna designs of "a more practical length for today's airplanes" has been announced by Goodyear's Advanced Electronic Center, Litchfield Park, Ariz. The system, says Goodyear, permits instantaneous viewing of selected areas at extended ranges.

Ten airport surface detection radars ordered for busy fields

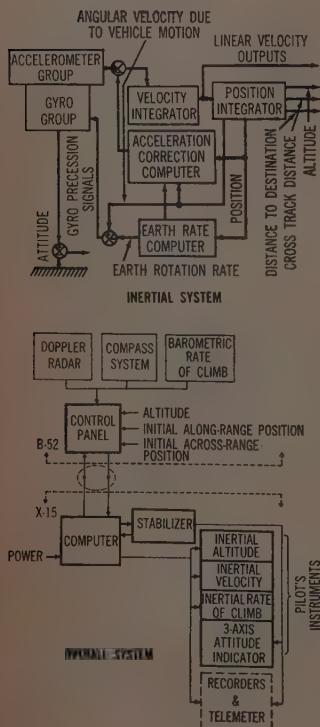
IN ONE OF its last official acts before it was absorbed into the Federal Aviation Agency, CAA ordered 10 airport surface detection radars from Airborne Instruments Labs for a total of \$1.786 million. Delivery will start in 18 months.

The ASDEs will be installed in the control towers of 10 of the nation's busiest airports. They operate on 24 kmc, with peak power between 30 and 50 kw.

ITT LABS TEAM'S subcontract for the F-108 interceptor's mission and traffic control (MTC) package stirred up lots of vitriolic comments within the industry against the misuse of the weapon system approach and political chicanery. After North American, the prime contractor, picked the Collins Radio team for the subcontract, Wright Air Development Center turned thumbs down and insisted on ITT Labs.

Reason was that Collins' proposal did not

more on page 126



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High performance hydraulic pumps by Eastern are uniquely suited to the exacting operating requirements demanded in the craft of tomorrow.

Check these Eastern gear pump features — do they suggest a solution to your present design problem?

Small size: Eastern gear pumps are the smallest, lightest made. Airborne servo system pump shown delivers 1.5 gpm @ 1500 psig — measures only 1 $\frac{1}{8}$ " X 1 $\frac{1}{8}$ " X 2 $\frac{3}{4}$ ", weighs 9 oz.

Wide performance range: pumps available have theoretical displacements from .0016 to .0419 cu. in. per revolution — flow from .025 to 2.0 gpm, pressures from 0 to 2000 psig, at speeds to 24,000 rpm. Weights with motor range from 1.5 to 8.5 lbs.

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Flexibility, economy: mass-produced components can be teamed into the precise configuration you need. Creatively-engineered custom pumps also available.

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include enough USAF-developed equipment—in particular, the ARC-68 HF and ARC-62 UHF comm sets and their data links. Under ITT/Labs' proposal, Hughes Aircraft will supply the ARC-68 and RCA the ARC-62—developed for USAF.

Military's veto in systems management decisions

QUESTION IS, should the military veto a weapon system contractor's decision as to what is an acceptable proposal from a subcontractor? USAF apparently feels certain design and performance standards it has set must be met no matter what the prime contractor thinks.

So far, no official statement has come from any of the parties involved.

AS A RESULT of the F-108 MTC tempest, word has filtered down that apparently USAF is not sure whether the prime comm and data link system will be HF or UHF. At first, it is believed, HF was selected for the primary system and UHF for backup. Now, industry sources say, the roles may be reversed because of HF reliability problems.

IMPROVED automatic impact predictor developed by Packard-Bell for Aerojet-General take over from the radar-plus-telemetry method of keeping track of test missiles. Costing about \$300,000, or 90 per cent less than existing range-safety systems, it is a data processing complex that takes direction data from a Cotar tracker, converts it to a form suitable for a general-purpose digital computer (Bendix' G-15), and presents missile position directly—by means of digital analog converters—on various readout devices.

The first system is being installed at Vandenberg AFB, Calif. P-B expects about 97-98 per cent reliability.

Transparent TV screen combines functions of windshield and instruments

NAVAL RESEARCH LAB is experimenting with new transparent TV screen that lets you see not only the surface image but also the objects behind it. A result of ONR's aircraft instrument simplification program, the thin screen would replace present windshield. Pilots looking at the screen would see through it and receive information from instruments at the same time.

The screen was developed by NRL's Dr. Charles Feldman. He says it lets you view TV in bright daylight with little loss of contrast. The trick was in the coating. Using diffusion pumps, gages, and other equipment produced by Consolidated Electrodynamics, Dr. Feldman pro-

duced specially coated test screens. He deposited phosphor on the screen faces in the form of thin transparent films, which don't burn out as easily and present a sharper image than standard screens.

BECAUSE ARDC feels adaptive controls are the answer to automatic flight for future vehicles, USAF is making a concerted effort to spur R&D in this area. Some 450 experts from industry, government, and universities met on January 13-14 with the Flight Control Lab people at WADC to define the state of the art and exchange technical information on adaptive techniques.

Because of their non-linear nature, adaptive systems are quite hard to analyze. Most systems today are built on some theory, though with a good deal of trial and error. Even the definition adaptive controls isn't agreed upon. WADC roughly defines an adaptive system as one that "maintains required performance throughout the entire flight regime of the vehicle, doing so in closed-loop fashion, requiring no aerodynamic data and only a minimum of information about the vehicle".

OVER THE LAST THREE YEARS, USAF has let adaptive control contracts to Aeronutronic Systems, Cornell Aero Labs, Dodco, Lear, Minneapolis-Honeywell, MIT, Sperry, and UCLA. NASA, the Army Signal Corps, and GE are also doing substantial work in this area. Autonetics, which has the contract for automatic flight control for the F-108 and B-70, is expected to use adaptive systems.

To date, M-H has the most flight time on its system (some 60 hours). Flights have been in a Lockheed F-94C. Test pilot reports are encouraging.

Digital checkout system said to cut down on Atlas countdown

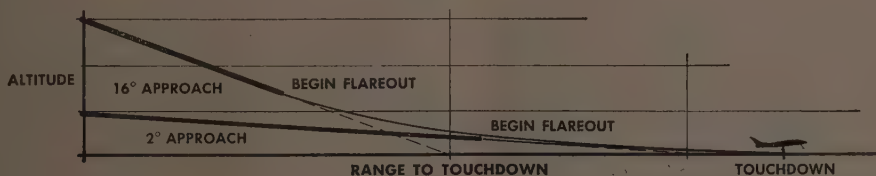
USING THE SPEED and accuracy of digital computing techniques, RCA came up with an electronic checkout system that reportedly makes Atlas' countdown procedure virtually a "ready-alert" step. Under subcontract to Convair-Astronautics, RCA is installing the first system at Vandenberg AFB, Calif. The highly classified system controls all steps of the countdown from a single pushbutton console. Differently colored indicator lights tell the operator whether the particular system selected for checkout is ready.

Built-in safety circuits insure proper sequencing of events. The engines, for instance, can't be started until the fuel tanks are topped off, and the missile can't be launched until engines are operating normally.



**getting
back
is important, too...**

...With costly airplanes and missiles, the descent is just as important as the flight. Autonetics' all-weather AUTOFLARE (automatic flare control system) takes over at sinking rates as high as 100 feet per second and airspeeds as great as 250 knots...makes safe zero-zero landings truly automatic. Entirely self-contained, AUTOFLARE requires no data links or radio commands.



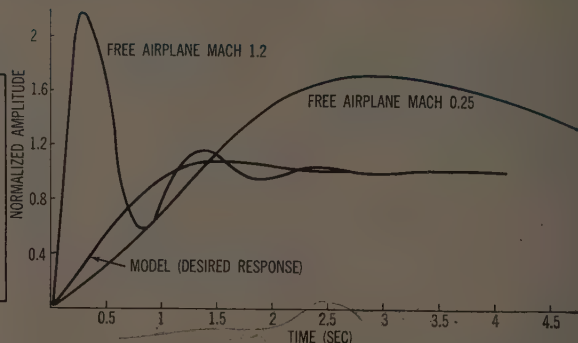
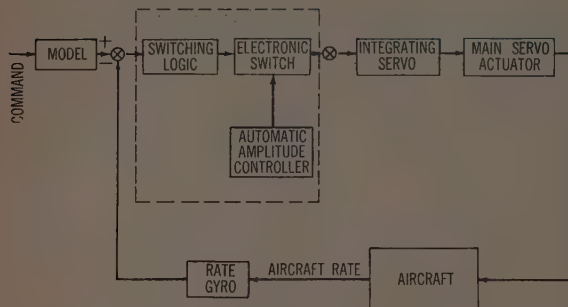
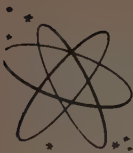
AUTOFLARE—adaptable to a variety of manned or unmanned airframes containing autopilots—has been proven by more than 1000 successful AUTOFLARE-controlled landings of jet fighters and supersonic missiles.

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FIGURES 1 & 2: Block diagram of an adaptive pitch rate control system (left) shows how adaptive autopilot works. Right: Typical transient response of model and free plane

(i.e., one without a flight control system) at sea level. Inputs are step commands. The model is an electric network analog of the desired response.

Adaptive control

new concept in automatic flight

Control systems that do not need to be tailored to the vehicle but can be easily adapted to a wide range of installations and are simple and reliable as well loom as the most significant recent advance in automatic flight. Applicable to anything from lightplanes to spacecraft, the new concept has already caught the eye of the military.

by **R. C. K. Lee, L. T. Prince & R. N. Bretoi**

Development Engineer, Project Engineer & Research Supervisor, Flight Control Group, Aeronautical Div., Minneapolis Honeywell Regulator Co.*

THREE AND A HALF YEARS AGO, Minneapolis-Honeywell started an R&D program to develop an adaptive flight control system. Its aim was an automatic system:

- independent of air data information (Mach number, dynamic pressure, pressure altitude) in its stability over wide speed and altitude ranges,
- performing as well as or better than conventional systems with "optimized" feedback gains,
- not adversely affected by design mods of the aircraft or missile carrying it,
- not requiring accurate aerodynamic data—on the vehicle, that would carry it—for design,
- more reliable and easier to maintain than existing systems.

M-H realized that a point of diminishing returns had

*Minneapolis-Honeywell Regulator Co., 2747 4th Ave., S., Minneapolis 8, Minn.

Adaptive Autopilot for Drones and Lightplanes

Besides the adaptive control system it is developing for high performance fighters and missiles, M-H has been working on a lightweight version for low performance airplanes and drones. A unique feature of the system is its pneumatic on-off servos.

The concept has already been extensively studied on a REAC computer, and a three-axis breadboard model has been flying a Cessna 310 with "encouraging results," says M-H.

The pneumatic servos are standard actuators made by M-H's Chicago Valve Div. They operate off the pressure side of a standard engine-driven Pesco pump. Frequency response and force output are "more than adequate to control a vehicle of the 310 type," claims M-H.

Target price of the system is \$2000-5000, depending on installation requirements.

apparently been reached in the use of linear control techniques. Despite many years of effort, it is still very hard to get satisfactory performance without in-flight-adjustment of control system gains. On high performance vehicles, this has involved the complexities of obtaining accurate air data and computing compensating factors covering the effect of the variations of these parameters on vehicle stability.

M-H studies (later backed up by simulator and flight test results) showed the adaptive autopilot would give excellent control over a wide range of flight conditions. If a self-evaluating feature is added, certain adjustments can be automatically made in the system to extend the desired stability and control characteristics over an even much wider flight regime. These in-flight gain adjustments are very different from those of conventional flight control systems—they require neither air data measurements nor moving mechanical parts.

In some respects, the system adapts itself to its vehicle craft just as the human pilot adapts himself to the particular flight characteristics of his airplane. The pilot generally tries to control his plane according to his mental standard of control performance. He adjusts his reactions so that, as far as possible, the aircraft response will be just what he wants. It doesn't take him long, for example, to find out whether he has an airplane that is slow to respond to his control inputs or whether it is highly sensitive.

The adaptive control system is based on similar principles—it "knows" the desired aircraft response and it adjusts the control signals to give these responses throughout the flight regime.

To understand the workings of an adaptive autopilot, let's look at its pitch stability augmentation loop. The basic loop (Fig. 1) consists of a model, an adaptive controller, a servo actuator, a surface actuator, sensing elements, the airplane, and the control stick. The self-

more on next page

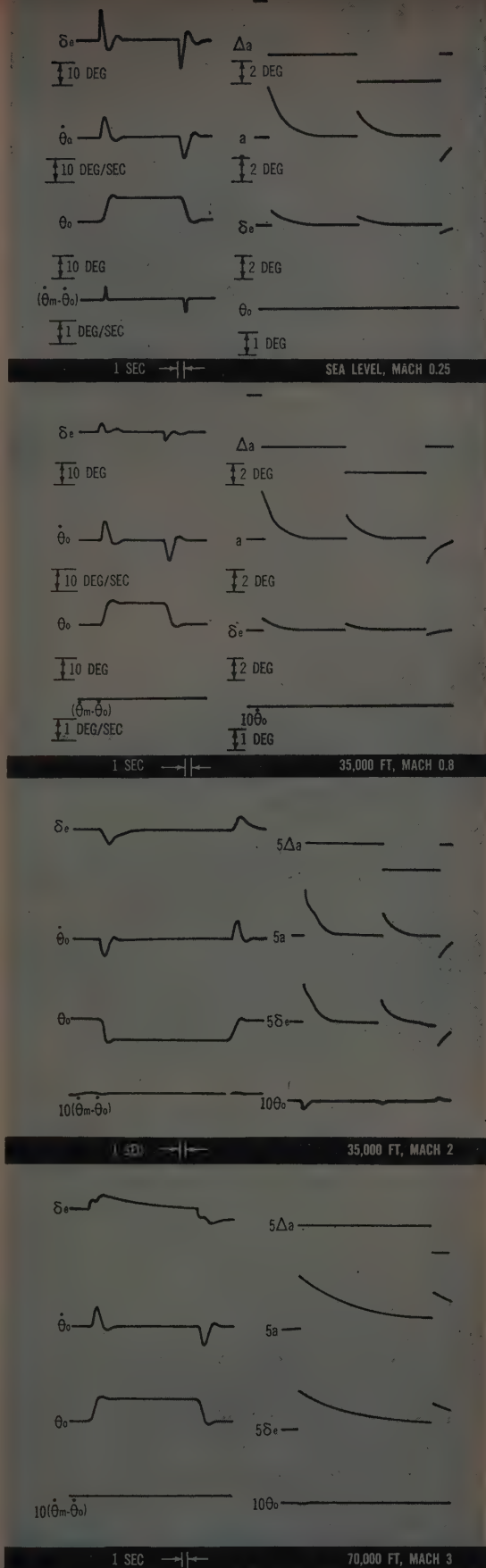
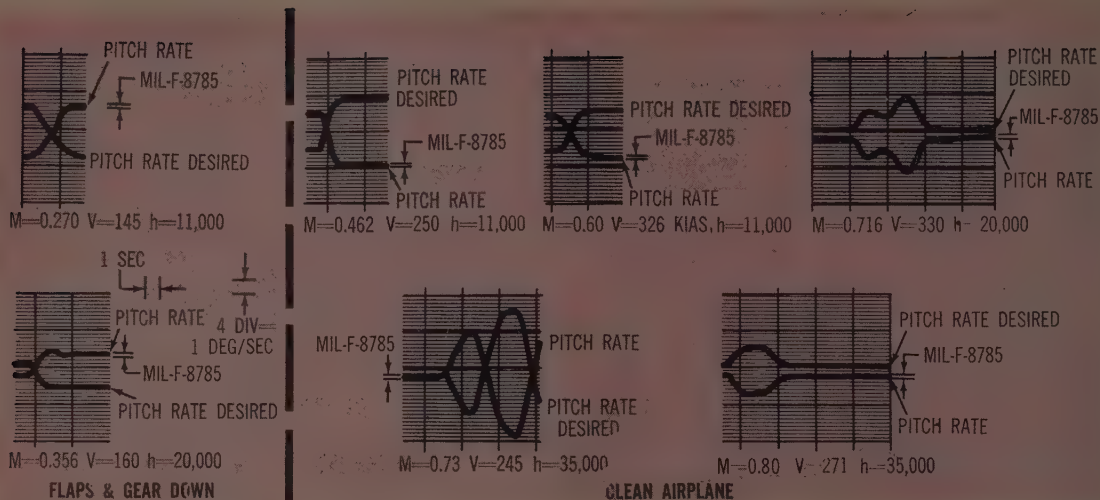


FIGURE 3: Pitch attitude and command and gust disturbance where θ_o is 10 deg and disturbance (Δa) is +5 and -2.5 deg.



evaluating feature is gotten through the amplitude modulator, a part of the adaptive controller.

The model provides an electrical analog of the selected flight performance standard. It represents what the pilot actually wants in the way of aircraft handling characteristics. Studies by Cornell Aeronautical Lab, NACA and, M-H (to a lesser extent) show that the pilot prefers an aircraft that is slightly underdamped (so that he can track his target easily) and has a natural frequency high enough for quick maneuvering and easy control.

For the pitch axis, we found, a second-order system with a damping ratio of 0.7 and a natural frequency of three rad/sec was best for most cases. The model is a simple electric network whose output voltage represents the desired aircraft performance, or the response the pilot would like to get for a given input. The transfer function of such a model is: $\text{model input/model output} = \omega_n^2 / (s^2 + 2\zeta\omega_n s + \omega_n^2)$, where ω_n is the natural frequency of the model; s , the Laplace variable; and ζ , the damping ratio.

Figure 2 compares the transient responses to step commands of a typical second-order model and of a plane without automatic flight control.

Electric commands to the model come from a stick force transducer mounted on the plane's control stick. As the pilot applies stick forces, he generates proportional voltages and sends these as signals to the model.

If the plane flies so that it exactly duplicates this performance, then, of course, it flies the way the pilot wants it to fly. To achieve just this the job of the adaptive controller—it makes the plane follow closely the output of the model. In pitch rate control (the channel under discussion) it continuously compares the desired airplane response, or model output, with the actual pitch rate of the aircraft as detected by the pitch rate gyro. The difference, or error signal, goes to the pitch rate controller.

The adaptive controller is made up of a compensating network, a bi-stable element (the electronic switch in Fig. 1, physically a transistor flipflop circuit), and an

amplitude modulator. The compensating network is a phase lead circuit that operates on the error signal to provide some anticipation. Its output feeds the bi-stable element, which acts as a mechanical relay, switching the servo to one of two voltages. These are equal in magnitude but opposite in phase.

So long as the input is positive, the bi-stable element selects the servo-driving voltage phase that moves the control surface at a constant rate in one direction. When the input changes sign, the element switches to the opposite phase, and the control surface is driven at a constant rate in the opposite direction. This non-linear action keeps the error signal small at all times; as a result the response of the airplane closely resembles that represented by the electric networks of the model.

Control systems that contain bi-stable elements all have a small-amplitude residual motion that can be used to evaluate certain characteristics of the system. The magnitude of this residual aircraft angular motion is proportional to the control surface effectiveness times the fixed surface rate commanded by the output of the bi-stable element.

Controller is a digital device

By keeping the residual motion at a very small but constant amplitude, the product of surface rate and surface effectiveness is held constant. As the surface effectiveness changes (because of changes in aircraft speed and altitude), the commanded control surface rate is changed accordingly—the available surface rate is small when control effectiveness is large and vice versa. The changes in available surface rate are made through the amplitude modulator, which changes the magnitude of the output voltage from the bi-stable element.

The adaptive controller is essentially a digital device that commands a surface rate that is either positive or negative but of a fixed magnitude at a given flight condition. The intelligence that causes the commanded

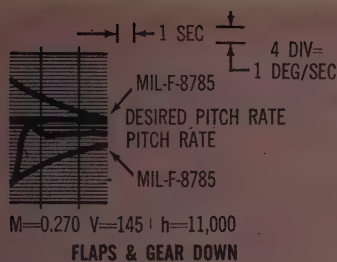
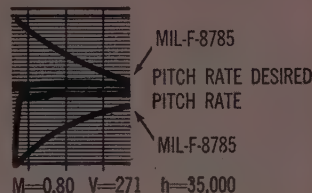
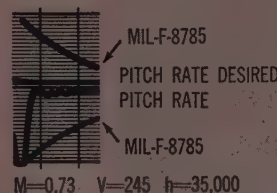
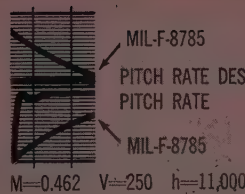
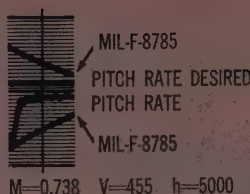


FIGURE 4: Flight test results with adaptive autopilot. Gust response curves were obtained by overpowering the control. "Desired pitch rate" is the output from an analog model installed to show the theoretical ideal response defined by a damping rate of 0.7 and a natural frequency of three rad/sec.



CLEAN AIRPLANE

surface rate to vary discontinuously—i.e., the signal that flips the bi-stable element, changing the sign of the servo drive voltage is a function of the difference between desired and actual aircraft response as measured by the sensing element.

Through the use of a non-linear element, the tight loop needed to minimize errors to commands is obtained without the usual stability problems of high gain linear systems. Our system has a unique characteristic: for small errors the gain is large, for large errors the gain is small. This means it will operate at maximum bandwidth for small errors (good following of the model), yet at low bandwidth will have sufficient phase margin for good response to disturbance inputs such as gusts. In addition, wide variations in the airplane's static stability and damping have negligible effect on system performance.

Another feature of the adaptive control is that outer loop control functions—such as altitude and attitude hold—become very simple. This is because the dynamic behavior of the plane is made uniform by the adaptive control feature provided in the inner loop.

Roll control with the adaptive system is similar to pitch control. However because, in roll an aircraft responds like a first-order system, the model for roll represents a first-order transfer function.

The circuits of the adaptive autopilot use semiconductors and high performance magnetic amplifiers. This has cut size and weight substantially over vacuum tube systems. For example, a basic three-axis system (not including actuators) that provides attitude hold, altitude hold, damping, and pilot command functions can be built to less than 40 lb total weight and 1200 cu in. total volume.

Studies of the adaptive system developed for USAF's Wright Air Development Center show that it will give uniform dynamic response without gain scheduling over the flight regime of a hypothetical but typical Mach 3 delta fighter.

The Table gives the pitch axis' dynamic parameters that define the aircraft characteristics for a number of

Parameter Variations*

Altitude (ft)	Mach No.	$\left(\frac{\dot{\theta}}{-\dot{\theta}_0}\right)_{ss}$	ω_n	ζ_n	T_n	ω_m	ζ_m
SL	0.25	0.84	0.68	0.51	2.16	3.0	0.7
SL	0.8	3.48	2.11	0.58	0.55	3.0	0.7
SL	1.2	2.10	6.25	0.30	0.33	3.0	0.7
35,000	0.8	1.50	0.97	0.34	2.25	3.0	0.7
35,000	2.0	0.42	4.27	0.10	1.55	3.0	0.7
70,000	2.0	0.15	1.81	0.06	8.37	3.0	0.7
70,000	3.0	0.12	1.73	0.08	9.33	3.0	0.7

*Where ω_n , ζ_n , and T_n are defined by the short period pitch rate to elevator transfer function:

$$\dot{\theta} / -\dot{\theta}_0 = -M\dot{\theta}_0 (s + 1/T_n) / (s^2 + 2\zeta_n\omega_n s + \omega_n^2)$$

in the steady-state case:

$$(\dot{\theta} / \dot{\theta}_0)_{ss} = M\dot{\theta}_0 / T_n\omega_n^2$$

and ω_m and ζ_m describe the model, whose transfer function is:

$$\dot{\theta}_m / \dot{\theta}_0 = \omega_m^2 / (s^2 + 2\zeta_m\omega_m s + \omega_m^2)$$

where $\dot{\theta}_m$ is the model rate and $\dot{\theta}_0$ the command rate.

widely varying flight conditions. The analog results of Figure 3 show the performance of the adaptive control system throughout the flight range.

Theoretical studies and simulator trials were corroborated by flight tests in a Lockheed F-94C. Uniform dynamics were achieved throughout the flight envelope, steady state stability was good, and gust response was satisfactory over the whole regime. (Fig. 4).

The first supersonic trials of the system will begin in late February or early March in a McDonnell F-101. A low cost, lightweight modification of the adaptive autopilot is undergoing flight tests in a Cessna 310. This system uses pneumatic on-off servos (see Box). Write in No. 58 on Reader-Service Card for more information.—End

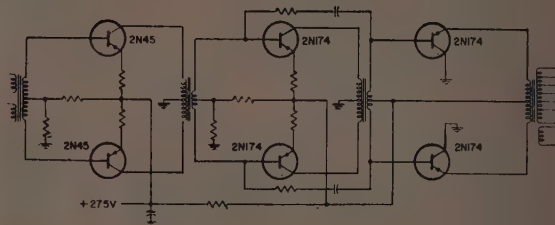
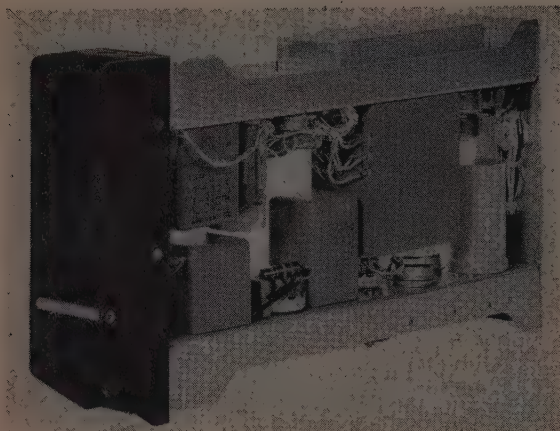


FIGURE 1: Collins passenger address amplifier 346D-1 shows simple design made possible by power transistors. Six transistors are used to get 40 W output. (Tone controls and priority switching circuits are not shown in the schematic.)

Design tips on **transistors** in airborne equipment

Only during the last year have transistors come into wide use in airborne equipment. What problems does this relatively new application raise? Here is answer to this question, based on flight and lab tests and polls of Collins' customers.

by **Mel Caquelin,**

Head, Research & Development Group, Collins Radio Co.*

DESIGN PROBLEMS with transistorized airborne equipment generally stem from two sources: (1) inherent limitations of the transistor and (2) the environment in which the equipment must operate.

Although the transistor is mechanically rugged, it must be used carefully under extreme temperature and electrical condition. It can't take the "beatings" that

tubes and rotating devices have withstood for so many years.

Specifically, the designer must watch out for:

- the temperature limitations of transistors as well as high external ambients and internal increases;
- operation over a wide range of line voltages, including positive and negative transients,
- instability with changes in temperature, line voltages, etc.;
- vulnerability under repeated short duration overloads (as are produced when motors are started or lamps lit) and shorted overloads during a fault;
- noise radiated from square-wave switching devices in transistor power supplies (this "hash" plays havoc with sensitive receivers in the aircraft);
- large performance variations from transistor to transistor;
- the low impedance of transistors (which makes filtering more difficult—for example, larger capacitors are needed—and because of which little isolation is offered through an amplifier stage and lower resistances in transformer windings have to be specified);

* Collins Radio Co., 855 35th St., N. E., Cedar Rapids, Iowa.

- power line modulation (where high power Class B audio stages are powered directly from a 27.5-Vdc line, the performance of the audio stage may deteriorate and the power line may be modulated, unless the power line source impedance is very low);

- loss of efficiency because of the compensating circuits used for operation over environmental extremes and to reduce noise;

- "single source" problems (from the equipment designer's point of view, most transistors are actually "single source" items and subject to change, deletion, or replacement with a "similar" type with little notice);

- high costs (the initial cost of transistorized equipment is usually higher than that of the equipment it replaces, but this often does not hold for the long range).

A good example of a transistorized design now in production is the Collins 346D-1 passenger address amplifier (Fig. 1).

The unit can deliver 40 W average sine-wave power (80 W peak) over a 10-kc band at low distortion levels. It fits into a short ¼ ATR case and weighs 9.6 lb. Only six transistors are used, and there is not a single resistor or capacitor in the output stage.

How heat problems were licked

The 346D-1 operates directly from the line, so it needs no separate power supply. Since it draws current only when keyed, the weight and added components of an ac supply couldn't be justified. Even when keyed, only a small amount of current is drawn—except on voice peaks—because operation is Class B.

The temperature limitations of the transistors played a major role in the design of the 346D-1. Here are

some of the steps we took to make up for these limitations:

- A grounded collector circuit was chosen for the output stage to get maximum heat conduction from transistor to chassis.

- The mechanical layout was arranged for best thermal performance. The transistors in the final stage were mounted on the front side of the front panel—the coolest spot in the equipment. The other transistors were mounted near the bottom of the set, as far removed from the output transistors and transformer as possible.

- Black heat radiation fins, extending out two inches, were attached to the front panel.

- The amplifier stages were operated Class B.

- The output transformer impedance ratio was chosen for maximum efficiency rather than maximum unclipped power output. (This cuts actual dissipation in the transistor by half but insures the required 40-W unclipped power output. Interestingly, dissipation in the transistor is actually higher when the unit is driven to only 20 W. This is because at 20 W more time is spent in the high dissipation area of the operating characteristic curve. Of course, this applies more to sine waves than to voice or music inputs.)

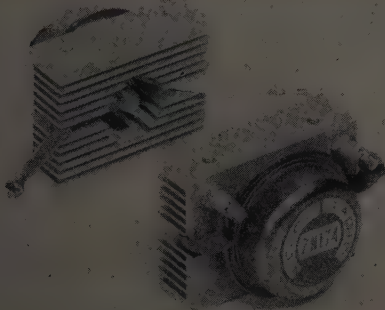
Another important point is the impedance of the aircraft power supply. Since the average power this unit draws from the aircraft is small, the higher currents drawn on voice peaks may modulate it so sharply that this modulation appears in the other units and audio systems powered from the same line. To bypass this modulation, a 200-ufd capacitor was placed across the primary bus and ground inside the 346D-1.

In general, cascaded transistor audio stages may

more on next page

FIGURE 2: Power Supply 516D1 was designed for insertion into Collins VHF transmitter 17L-7. Operating from 27.5-Vdc input, it delivers 210-470 V dc output. It is rated for 100 W.

FIGURE 3: Transistors mounted on heat sinks, a cooling technique used for operation at high temperatures. Forced air can be directed over the fins to carry away the heat.



Equivalent Transistorized and Dynamotor Power Supplies

Weight: Transistorized unit is 50 per cent.

Size: Transistorized unit requires 50 per cent less volume with more desirable shape factors.

Efficiency: The dynamotor unit is only 60 per cent less efficient.

Initial Cost: Purchase price of the transistorized unit may be 100 per cent higher.

Expected Life (without maintenance): Probably 1000 per cent longer for the transistorized unit.

Audible Noise: No noise with the transistorized unit, considerable noise with the dynamotor unit.

present problems. A change in load on one stage may affect operating conditions at a remove of several stages. Also, the impedance an amplifier stage wants to see looking either forward or backward is quite critical. This makes it difficult to match stages without taking considerable losses from feedback with transformer coupling or from I^2R with resistance coupling.

"Interchangeability" is a myth

The large variations in characteristics from one transistor to another of the same type are another headache. Even though characteristics may coincide at one set of conditions there will be a variation in gain from transistor to transistor with changes in collector current and temperature. Unfortunately, most transistors on the market are still single-source items. Very few advertised claims of "interchangeability" between units made by two or more manufacturers have actually been made good.

Although manufacturers usually show typical curves for the characteristics of their transistors, the actual gain limits are given for only one set of conditions. Naturally, this is never the one you are interested in.

Another problem is prestabilization. You should first find out whether the transistor you intend to use has been baked (prestabilized) and whether the manufacturer actually tests *all* his transistors for the characteristics that are critical in your design.

If necessary, special baking or testing arrangements may have to be made. Also, if the manufacturer doesn't specify limits near the required condition, a new set of limits might have to be worked up and new specs written.

Obviously, both these items would increase your costs. You will have to check just how critical your requirement is and then decide whether to gamble on a standard catalog transistor or to add more limits and testing and pay the extra price. Because of the broad limits on standard catalog units, the latter course is often necessary.

In airborne equipment, probably the greatest benefits from the use of transistors come in power supplies—converters (dc to dc) and inverters (dc to ac).

Rotary dynamotors and inverters used to be about the only adequate supplies available for airborne equipment, and now the power transistor is rapidly making them obsolete (see *Box*.)

An example of an airborne power supply now in use in airliners and large business aircraft is the Collins 516D-1 (Fig. 2), the dc supply for Collins' 17L-7 airborne VHF transmitter. Either an ac or a dc supply module may be plugged into the power supply position in this transmitter.

The 516D-1 is rated for about 100-W with 210- and 470-V dc outputs. Its dimensions are $2\frac{15}{16} \times 3\frac{1}{4} \times 4\frac{1}{16}$ in., and it weighs $2\frac{3}{4}$ lb.

To meet CAA TSO requirements, the unit had to be able to operate continuously at 71 deg C for half an hour. The actual temperatures of the components in the power supply—as well as of those in the rest of the transmitter—were studied in detail with thermocouples under various operating conditions to make sure the critical temperatures weren't exceeded.

To generate minimum heat, the control circuit (in the transmitter) was designed so that power is applied to the transistors only when the transmitter is keyed. Also, the collectors of the transistors were mounted directly to the heat sink (without insulating washers) for maximum heat transfer (Fig. 3). To dissipate the heat still further, air is forced over the fins of the heat sink whenever the transmitter is keyed.

One of the most troublesome limitations of the transistor—especially in power supply circuits—is failure due to overvoltage. The worst transients on a 27.5-V dc aircraft line will reach a high of 80 V and decay to 30 V in about 200 usec. We found negative transients with the dc line actually going negative by more than 30 V.

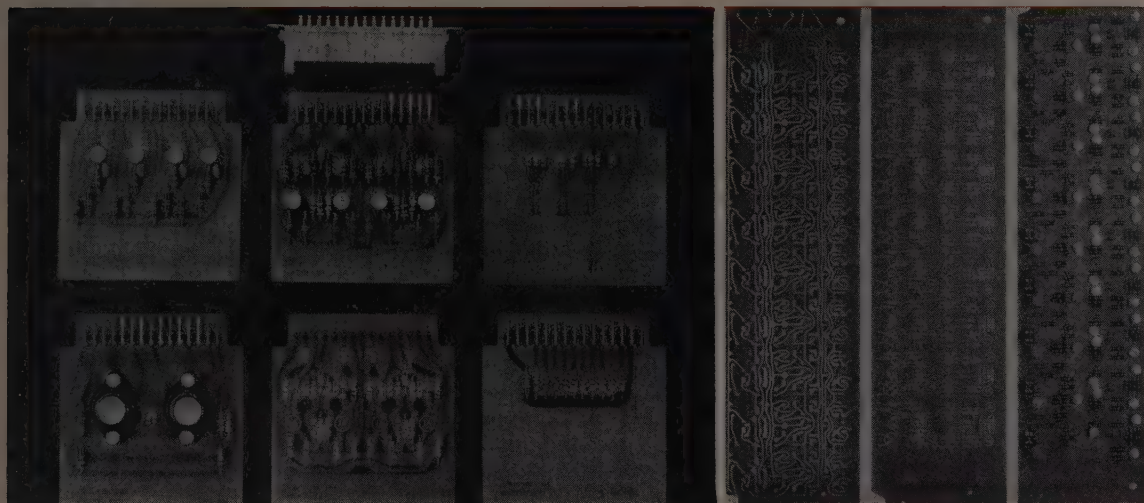
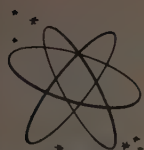
In the typical power supply circuit, the base-to-collector voltage will reach about 2.3 times the applied line voltage. So a transient much lower than 80 V would cause the maximum voltage rating of the transistor, usually about 80 V, to be exceeded. Transistors with 100-V ratings are usually available at premium prices, but this extra 20 V is not the solution to the problem. Even this 80 V rating applies only under certain biasing and temperature conditions. It's not unusual for a transistor to fail with the first transient that exceeds its collector-to-base voltage rating when proper circuit techniques were neglected.

Collins has studied aircraft power line transients and their effects on transistors and come up with several techniques for solving the problem. On the 516D-1, a series blander was used. A transistor carrying the input current to the supply is controlled by a second transistor so that the overvoltage pulses are blanked out before reaching the switching stage.

In the Collins 416N-6 transistorized dc supply, the switching stage uses four transistors in a bridge configuration that is relatively insensitive to transients. Another technique relies on voltage reference diodes.

There are several diodes on the market for dissipating high power levels, and these can be used in some circuits for transient elimination.

Intermittent overloads have also been a major cause of transistor breakdown. To guard against overloads in the 516D-1, the circuit is designed to stop oscillating during intermittent overloads. This keeps the switching transistors from drawing heavy current. However, it doesn't protect against a sustained short circuit across the output.—End



EYELETS and plated-through holes are eliminated in Packard-Bell's etched circuit design (left). Instead, as shown by these typical checkout system modules, the circuitry is etched on one side and the components are

mounted on the other. The leads are inserted through the holes and then soldered. Right: The use of large, etched circuit modules in solid state checkout systems greatly increases reliability, it is said.

Solid state system for fast automatic checkout

Electronic systems have become radically more complex in recent years—so much so that checking them out with trained personnel has become a major bottleneck. One answer to this problem is to make the checkout procedure completely automatic.

by **Max Palevsky and D. A. Domike**

Director, Packard-Bell Computer Corp., & Manager,
Missile Equipment Section, Technical Products Div.,
Packard-Bell Electronics Corp.*

WITH solid state switching devices it's now possible to build completely automatic checkout systems. These can be smaller, faster, more flexible, and more reliable (by several orders of magnitude) than semi-automatic electromechanical systems.

Figure 1 shows a generalized automatic checkout system. The primary data governing the test procedure is obtained from paper or magnetic tape or punched cards or is entered manually into a program register and sequencer. In certain cases, an internally wired or a patchboard program is appropriate.

The signals that act as inputs to the system under test can be generated in a number of ways. One of the

*Packard-Bell Computer Corp., 1905 Armacost Ave., Los Angeles 25, Calif.

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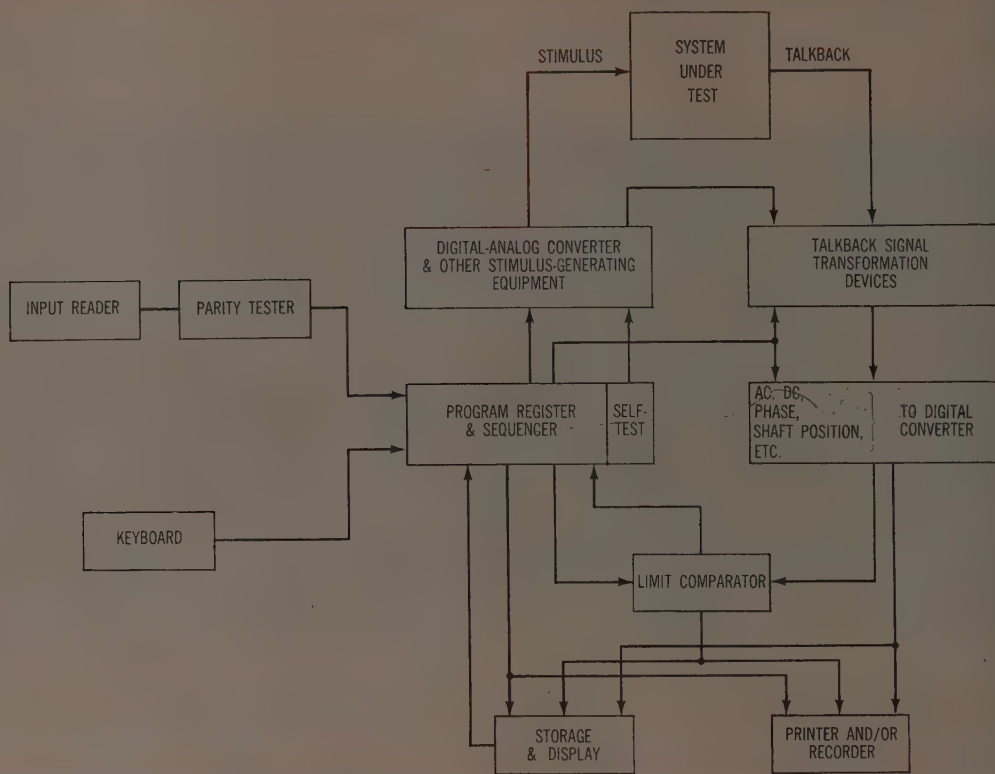


FIGURE 1: Generalized automatic checkout system.

most straight-forward is to use a digital-analog converter with transistor switches to transform a digital value in the program register into its ac or dc voltage analog. In many cases, however, special signals peculiar to the system under test must be generated. The number in the program register may then be used to turn on the proper signal generators.

After the correct signals have been fed into the system under test, the resulting talkback signals may have to be transformed before conversion into digital values. For instance, the output of transducers often needs correction for non-linearities.

Once transformed, a series of converters is used to convert the system response into digital form. The digital values are then compared with the limit values held in the program register, and the results are visually displayed and printed. These results and certain numerical data are also stored for use in subsequent steps. On the basis of the results, a decision is made that triggers the next step in the checkout.

A single checkout system is sometimes needed that will operate either manually or automatically but doesn't need automatic equipment in the manual mode. This has several advantages. Because the manual system is simpler and involves fewer components, it is more reliable than the entire system itself. This makes it more probable that one of the two modes will always be operative.

In addition, manual and automatic modes are suited

to different phases of a development and production program. A single system designed to serve both needs can save both time and money. This design objective is met in the Packard-Bell system—as far as possible, all automatic operations are concentrated in the register and sequencer. The mode of operation can be changed by either modifying or replacing this one subsystem.

Input devices supply the primary data

The input devices in *Figure 1* supply the primary information for the test. Error checking data is also stored, to provide a check for the reading mechanism. The simplest check is a single bit indicating the parity of the word being read. In certain cases, both horizontal and vertical parity are checked as in *Figure 2*.

A manual keyboard is included to give the system flexibility. It's often simpler to make last-minute changes in the test procedure manually than to prepare completely new sets of tapes or cards. A keyboard also permits modifications as a test proceeds.

Although flexibility is required for checking research and early production models of a system, it isn't needed in testing production models. It may, therefore, be appropriate to use a wired program for much or all of the test procedure.

The program register and sequencer is the central element of the system. Depending on the system, data about one or a number of steps may be stored at one

time. Storage can be provided by such means as transistorized flip-flops, magnetic cores, magnetostrictive lines, etc. In many cases, a combination of storage media is desirable. For example, a long block of information characterizing a large number of test steps may be read and stored in a core memory, while each step or sub-step is stored in flip-flop registers as it's used.

Acceptable talkback limits are stored either as an upper or lower limit or as a mean value and a tolerance. In some systems, all talkback signals are normalized so that only one limit or a small number of limits is required.

The register turns on the proper stimulus-generating equipment and sets it to the correct output. In addition, electronic switches may be set to channel the stimulus to the proper point in the system under test and to the right talkback transformation devices and converters.

Register can actuate the branch programs

The conduct of a test must often be modified on the basis of the test results themselves. The register must therefore be able to actuate "branch" programs, which may, for example, repeat certain steps and eliminate others. Certain test results require that specific shut-down procedures be started to protect the system under test. Storage must be provided for these in addition to the sequential gating system.

For self-testing the check-out system itself may be inserted as part of the original input data. An alternate approach is to automatically interrupt the normal checking periodically and perform an internally fixed self-test operation independently of the inserted program.

In either case, the stimulus bypasses the system under test and is directly processed by the talkback devices, a converter, and the comparator. Any faulty operation is localized on the display panel and stops or modifies the conduct of the test.

Depending on the system under test, a variety of stimuli may be needed. Besides digital-voltage converters, other signal-generating equipment includes high frequency generators with various types of modulators, motors to provide mechanical stimuli, pressure generators, etc.

As far as talkback signal transformation is concerned, many of these operations can be performed digitally after conversion, if sufficient digital computing facilities are available. However, it's usually simpler and more economical to do these operations directly on the analog talkback signals.

For systems needing an amplifier for each talkback signal, it's sometimes desirable to normalize all signals by adjusting amplifier gains. The same results can be obtained by changing scales at the input to a voltage-digital converter. Either method eliminates the need for programming limits, but reduces system flexibility, since gains must be modified as the test procedure is modified.

All the talkback signals must be converted to digital form before they can be compared to the limits held in the program register. For the high frequency transient analysis used to derive transfer functions and frequency spectrums, a very short sampling time is needed. Sampling times of a fraction of a microsecond are available with such systems as Packard-Bell's "Sample & Hold." Other converters must be used to convert the position of servos and synchros to digital form.

The magnitude of two digital numbers can be com-

	Parity
1001	0
1100	0
1000	1
0000	0
1010	0
0010	1
0111	1
0011	0
1001	0
Parity	1000
	1

FIGURE 2: Method of checking both horizontal and vertical parity for the input reader.

pared in several ways. One approach is to scan the two numbers from the more significant end and note the first position in which they differ. Another is to subtract one number from the other and look at the sign of the difference. This system yields the magnitude of the difference.

Upper and lower limits must be compared

Two limits, the upper and lower, must be compared. Depending on the available time and the speed of circuitry, the two operations can be performed either serially by one device or simultaneously by separate comparators. For very high speeds, completely parallel systems can be built.

The data used and generated by the test procedure normally is displayed on a test status board. If results are displayed only as they're generated, no storage is needed.

If data is to be displayed and held at each step, some form of storage is required. Solid state flip-flops, together with the power amplifiers needed to activate displays, can be used for this. Storage is also needed for the talkback information qualifying the operations of the sequencer.

The display also performs a diagnostic function in pointing out parts of the system under test that are inoperative or out of tolerance. It may also supply data on which operating decisions are based. For instance, where the use of marginal or out-of-tolerance systems may be necessary, it provides data from which success probabilities can be estimated.

All the units we have been describing, with the exception of some of the r-f generators and talkback transformation devices, can be made entirely of solid state active elements. The use of mechanical devices is minimized or eliminated. The dc amplifiers, for example, wherever possible use silicon transistors, rather than mechanical devices, for stabilization.

Depending on temperature requirements, the system can use either silicon or germanium transistors. Magnetic elements, such as shift registers and coincident current memories, are also available. Magnetic regulation is used in the system power supplies. Write in Number 61 on Reader-Service Card for more information.—End

design digest

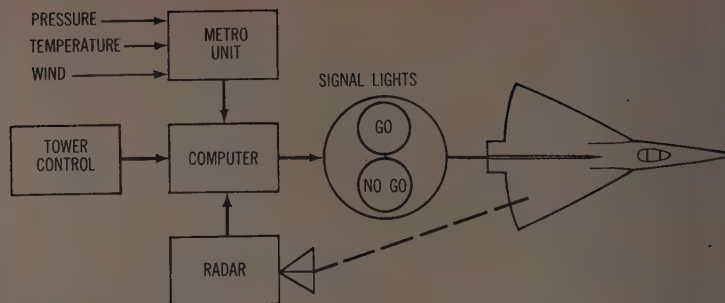


by **Bernard Kovit**

Associate Electronics Editor

Ground-based monitor improves jet takeoff odds

GROUND-BASED takeoff monitor conceived by Nortronics Div., Northrop Corp., Hawthorne, Calif., adapts to various aircraft. Using a metro unit to cover field variables, the system's analog computer initially calculates and displays normal ground roll. After plane starts down runway, Doppler radar locks on and continuously supplies acceleration and ground-speed data. Computer then figures takeoff capability for normal performance. Questionable performance in a safe-abort zone defined by the computer turns the runway go-no go lights red. Beyond this zone, system flashes red only when takeoff is impossible. Pilot always has final decision. Based on roughly three per cent error in present hardware and allowing for unpredictable variations in metro and aerodynamic conditions, system's ground-roll prediction accuracy should vary from about 10 per cent error in the pre-roll mode to much lower figures down the runway, says Nortronics. Write in No. 54 on Reader-Service Card for more information.



SIMPLIFIED DIAGRAM shows the functional relationship of the elements of the entirely ground-based takeoff monitor system. Nortronics arrived at its concept after studying reams of USAF takeoff accident data, getting pilots' views, and applying human engineering and dynamics analyses. Basic element of the system, with which Nortronics proposes to monitor all measurable takeoff parameters, is an analog computer. It digests the various inputs and cranks out a takeoff capability figure. "Line speed check" system commonly used for safeguarding takeoff is inadequate, says Nortronics, because it does not take aircraft acceleration into account. Doppler radar samples this in the proposed system.

HORIZONTAL FORCES on a Jet Aircraft during Takeoff Ground Run (ICAO units)

L = Lift

W = Gross weight of aircraft (lb)

D = Drag (lb)

e = Angle between thrust vector and runway

θ = Slope of runway (radians; positive down, negative up)

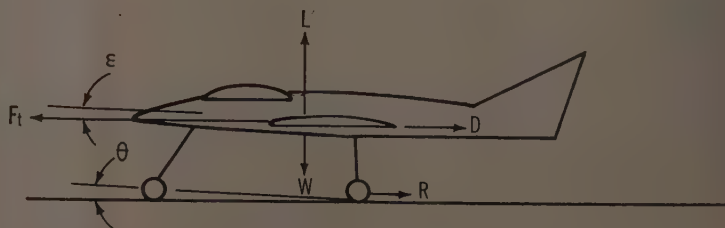
R = Surface rolling resistance (lb)

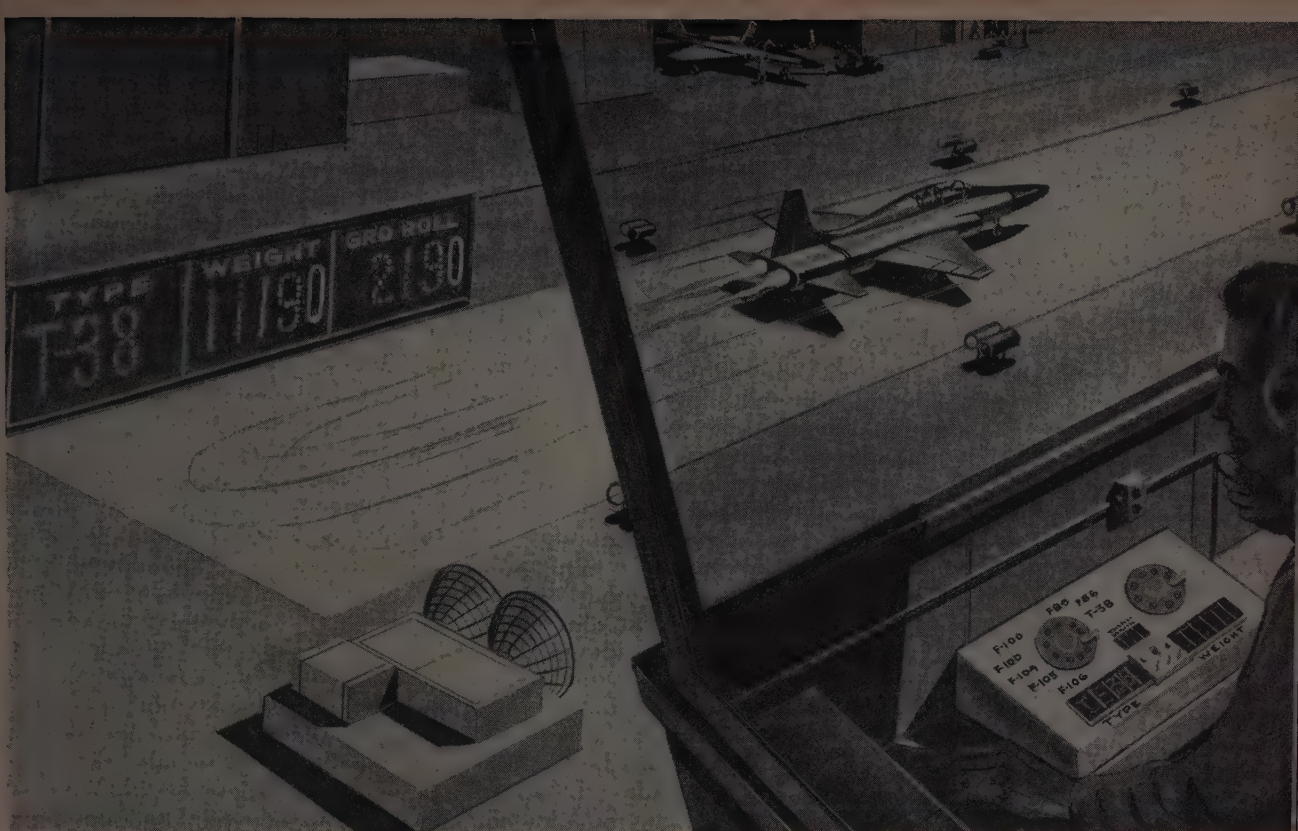
T_p = Propulsive thrust (lb)

Constructing the ground roll equation, you get:

$$\Sigma F_e = Ma = W/g a = T_p \cos e - D - R + W\theta$$

where M represents mass of aircraft; F_e , thrust force (lb); g, acceleration due to gravity (32.2 ft/sec²); and a, acceleration (ft/sec²).





SAFEGUARDING THE TAKEOFF—Artist's sketch shows relative simplicity of Nortronics' system. Units would be

made up of existing hardware. Ballpark figure for probable production cost is said to be about \$70,000.

COMPUTER'S ROLE—Essentially, the computer determines whether or not the aircraft can make a safe takeoff under the existing conditions. The answer is in the form of a "takeoff capability" signal sent to the pilot in the aircraft. Mechanization can probably be best understood through a plot of acceleration vs distance (below).

The expression for acceleration (a) is:

$$a = \sigma AV^2 + B,$$

where σ is a constant, and A and B are constants provided the coefficient of rolling resistance of the landing gear on the runway, the lift coefficient while on runway, and the slope of the runway are all constants. (Experimental evidence shows these values may safely be assumed to be constants, claims Nortronics.)

The slope of acceleration (da/ds) is represented by $2\sigma Aa$. This varies only with a , which is relatively constant. So the problem is one of comparing the square of the

minimum necessary takeoff velocity with the sum of present velocity squared and the computed area under the remaining part of the curve. Computation of this area is easily mechanized because of the constant slope and also because the distance remaining is relatively easy to find.

The expression for total computed velocity squared at the end of the runway (assuming that the aircraft remains on the ground to the end of the runway and that present performance is maintained) is:

$$(V_c)^2/2 = V^2/2 + a\Delta s + \sigma Aa(\Delta s)^2,$$

Takeoff capability can be given by:

$$TOC = 1/(\sigma 2\sigma)f(W)^2 - (V_c)^2/2$$

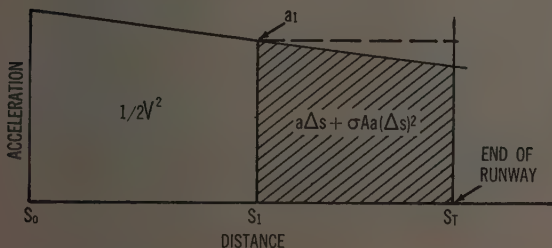
where $f(W)^2$ is the required indicated airspeed for takeoff. Constructing the complete equation, we get:

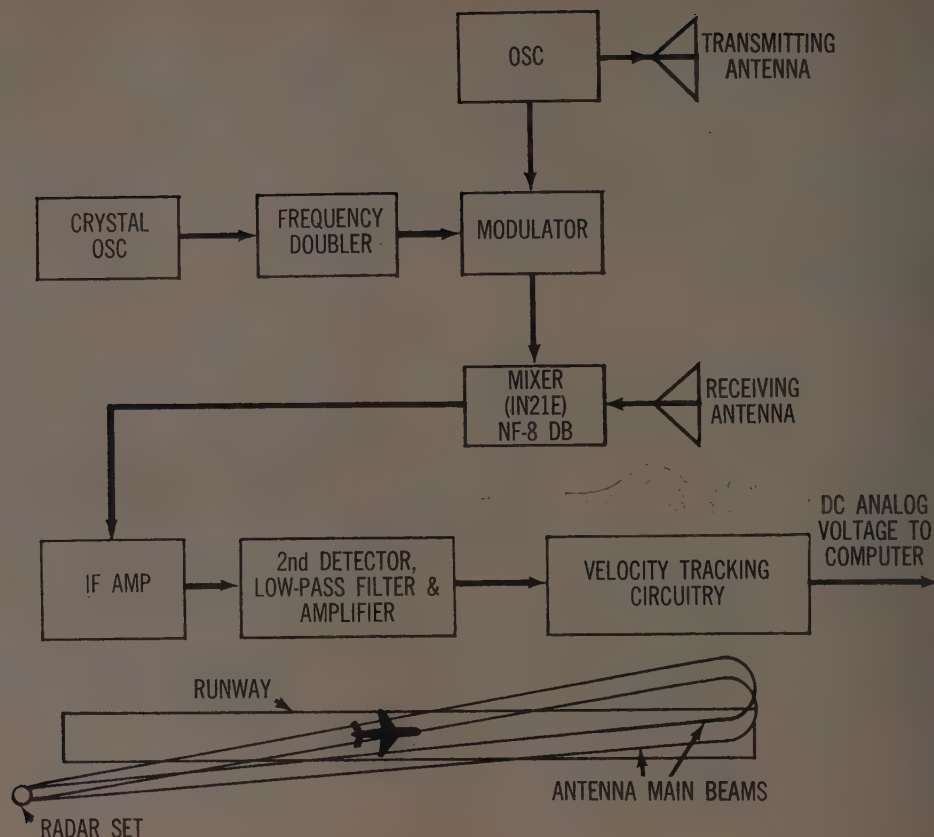
$$TOC = 1/(\sigma 2\sigma)f(W)^2 - (V_c)^2/2$$

where V_R and V_W are the velocities indicated by the Doppler radar and the metro unit, respectively.

The physical size of the analog computer in the actual system would depend on the number of types of aircraft it would have to handle and the degree of self-checking. The basic computation itself would require several function generators or servos. A relatively simple computer, occupying a space no larger than a standard relay-rack panel, should be quite adequate for the functions required, says Nortronics.

The computer analysis presented here reflects an interim phase in the ground monitor concept. Further refinements have been made as the result of an extensive error analysis, says Nortronics.





RADAR UNIT—S-band CW Doppler radar package monitors speeds from 40 to 250 knots (accuracy, one knot; max. acceleration, one G). A suitable transmitter is the 2C39B disk-seal triode, which puts out 15 W at this frequency range, says Nortronics. Dual antennas are aligned to approximate roughly a cose-

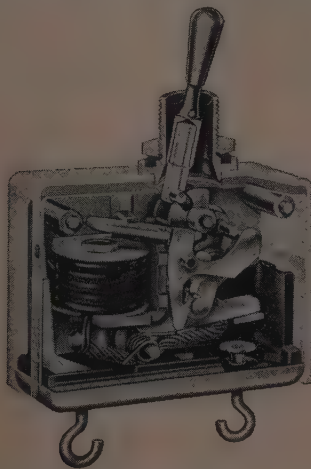
cant-square pattern, so that, moving away from the radar, the plane moves "into the beam," or region of greater antenna gain. The radar's output is a dc voltage proportional to the Doppler frequency—about 2000 cps at maximum. Accuracy is pegged at about 0.5 per cent.

MOBILE VERSION — To meet particular conditions at a given airbase, such as runway layout, number and relative position of strips, etc., a mobile field unit is proposed. This mounts the computer, radar transmitter and receiver, power supplies, removable antenna dishes and mounts, and barometric pressure instrumentation. A radio data link would connect it to the control tower. The metro instrument package (not shown) would be located halfway down the runway and connected to the computer by cables. All of this equipment, together with the runway readout display and go-no go signal lights, can be readily designed for all-weather operation, says Nortronics.

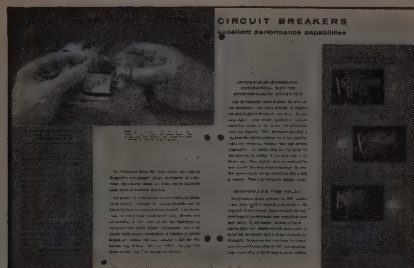




This is the actual size of Heinemann's new sub-miniature circuit breaker, the SM3. It is hermetically sealed, magnetically actuated, has been tested to the hilt for reliable operation under all kinds of uncomfortable environmental conditions, terrestrial and celestial. And with all this, it weighs just a scant 2.1 ounces.



This is how the breaker looks inside. As you can see, it has been deftly engineered down to the last pivot pin. What you can't see is how dependably it works, come heat or high water. For example: it will steadfastly hold rated current and set trip points at any ambient temperature, has demonstrated satisfactory operation from a frigid $-40^{\circ}\text{C}.$ to a steamy $100^{\circ}\text{C}.$ De-rating is never necessary.



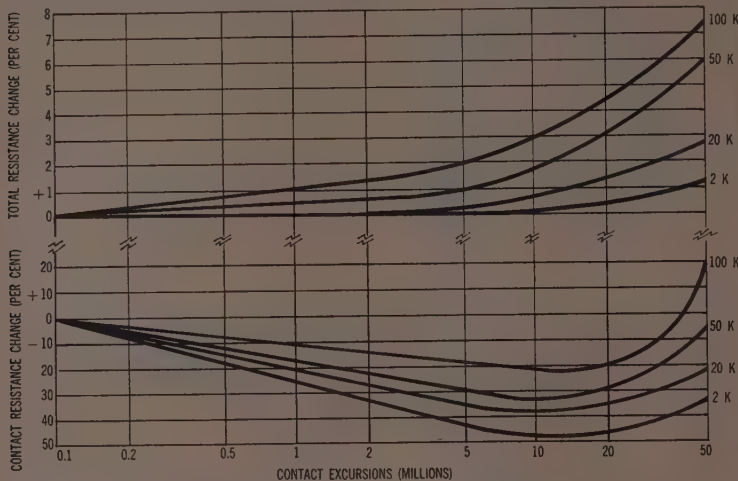
This is the book with the facts and figures you will want to have, if you think the rugged little SM3 will fit in with your portable, airborne or sea-going equipment. Clearly and concisely, it tells you about such things as available time delays (there are two, fast and slow), current ratings (0.050 to 10 amperes, integral or fractional), and voltage ratings (110V, 60 cycles; 110V, 400 cycles; 50V DC). We'll rush a copy to you just as soon as we receive your request for Bulletin 3502.

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TOTAL and contact resistance vs contact excursions for four ranges of Markite potentiometers.



RAHM Model 134 miniature pressure transducer, designed for severe missile environments with precision conductive plastic resistor.

Conductive plastic pots upgrade transducers

Rahm engineers claim they have extended the design potential of pressure transducers, once limited by the wire-wound pot. With a conductive plastic element, they say, they now get better wear, less contact resistance, and infinite resolution.

by James P. Hunt

Research Engineer, Rahm Instruments Div., American Machine & Metals, Inc.*

THE limitations of the wire-wound resistor have long bothered the designers of the electromechanical pressure transducers, in which a force collector-spring combination is used to position an electric contact along a resistive element. This headache is now being overcome through the application of

infinite-resolution potentiometers.

Infinite-resolution pots in displacement-type pressure transducers have been the target of considerable design and development work during the past few years. The result is the development of a series of low, intermediate, and high pressure transducers using the infinite-resolution concept. These instruments work in the range from 0-1 to 0-7500 psi.

Finding the right pot involved a thorough study of both semi-conductive and metallic deposit-film resistors. Several materials defined as "conductive plastics" were also studied. We found that a conductive plastic material produced by The Markite Corp., 155 Waverly Pl., New York 14, N. Y., suited the requirements best. Static and dynamic tests showed this material to have superior mechanical and electric characteristics.

The static and dynamic performance characteristics of any displacement-type transducer using a potentiometric output are closely related to the physical and electric

properties of the resistor. So let's start by reviewing the structural features of our new design. The significant performance factors to be considered in choosing a resistive element for pressure transducers are wear, contact resistance, friction, temperature behavior, and resolution.

You can best assess the phenomenal surface characteristics of the Markite conductive plastic by the total resistance change as a function of brush excursions (see *Graph*). Since the life of the pot far exceeds that of most pressure-sensing elements under continuous cycling, the overall life of the transducer depends on the sensing element.

If you evaluate the contact resistance change as a function of the total number of wiper excursions (see *Graph*), you get an idea of the unusual structural property of the Markite element. Also, the noise shown by this element is entirely different from that of the wire-wound pot. For one thing, no voltaic cell action occurs as the wiper moves across the turns of a wire-wound pot. The mechanical discontinuity of a wiper contact moving across an irregular surface is also absent. We attribute this to the extremely hard and smooth surface of the Markite element.

Of utmost concern to the user of the potentiometric device is the protection against an open circuit. With a wire-wound resistor, you can't give him any such protection. With a Markite resistor, an open circuit will not occur unless the element is completely destroyed through excessive power dissipation or mechanical failure of the wiper contact.

more on page 144

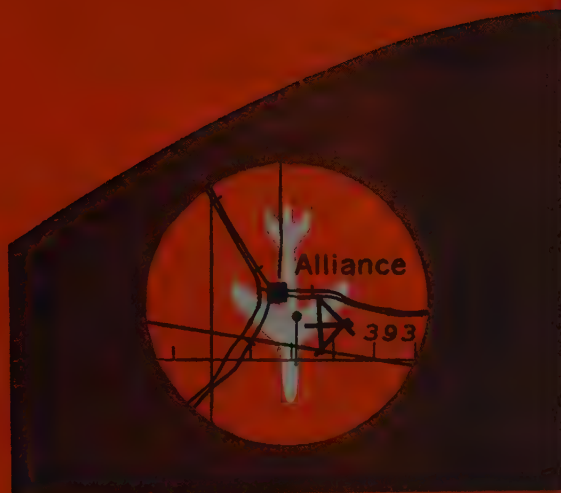
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TRANSDUCERS . . .

Circuit engineers have found that it largely depends on the coefficient of friction at the point of contact of the wiper and the resistive element whether they get its full static performance capabilities out of a potentiometric device. Actually the sensing element in a displacement-type transducer acts as a force collector, or prime mover. So if your sensing element must do appreciable work to overcome friction, it not only changes the characteristics of the spring element itself, but leads to large frictional errors. The extremely low friction coefficient of the conductive plastic pot enables the designer to use this type of resistor in high motion amplification transducers.

Fairly high contact forces possible

Another advantage of the low friction coefficient is that relatively high contact forces (20-30 g) can be used without significantly increasing the friction within the system of reducing the life of the unit. In contrast, a wire-wound pot needs contact forces of around 3-4 g for optimum performance.

You also benefit from the higher contact forces allowed by the conductive plastic elements when the transducer is subjected to vibration. It will perform under higher G loadings without discontinuities between the contact and the potentiometer.

Temperature tests on conductive plastic potentiometers show that the elements have a negative temperature coefficient (-0.0003 to -0.0004 ohm/ohm/deg C from zero to 100 deg C.). To minimize the resistance change, the elements can be shunted with a material that has a positive temperature coefficient.

Resolution measurements have been made on the Markite element to 4×10^{-6} in. This was not the limit of the conductive plastic pot, but rather that of the measuring apparatus. This high order of resolution gives you more versatility in meeting transducer requirements.

You can also design the transducer for small full-scale deflection, reducing the stress on the pressure sensing element and increasing the life of the instrument. The high resolution of the Markite element means you can now get pressure transducers of unprecedented high sensitivity.

A good example of this new breed of pressure transducers is a Rahm miniature unit consisting of a $\frac{1}{8}$ -in.-diameter, capsular pressure-sensing element (see photo). Through an articulate linkage, this element actuates the wiper of a precise conductive plastic resistor. The output, in terms of resistance ratio, is linearly proportional to the pressure input.

Bourdon-tube unit senses 7500-psi

Instruments in this group have been designed for a range from 0-15 psi to 0-300 psi in absolute, differential, and gage pressure configurations. They will operate reliably under severe environmental conditions (without any compromise of static performance).

For the higher pressure ranges, we have designed a transducer that uses a Bourdon tube pressure-sensing element. This unit is used for measurements up to 7500 psi of various media, including corrosive acids and reducing agents.

We have also used the conductive plastic element in a series of altitude and airspeed transducers. In certain special applications we have been able to obtain functionalized outputs from these instruments. Write in No. 56 on Reader-Service Card for more information.—End

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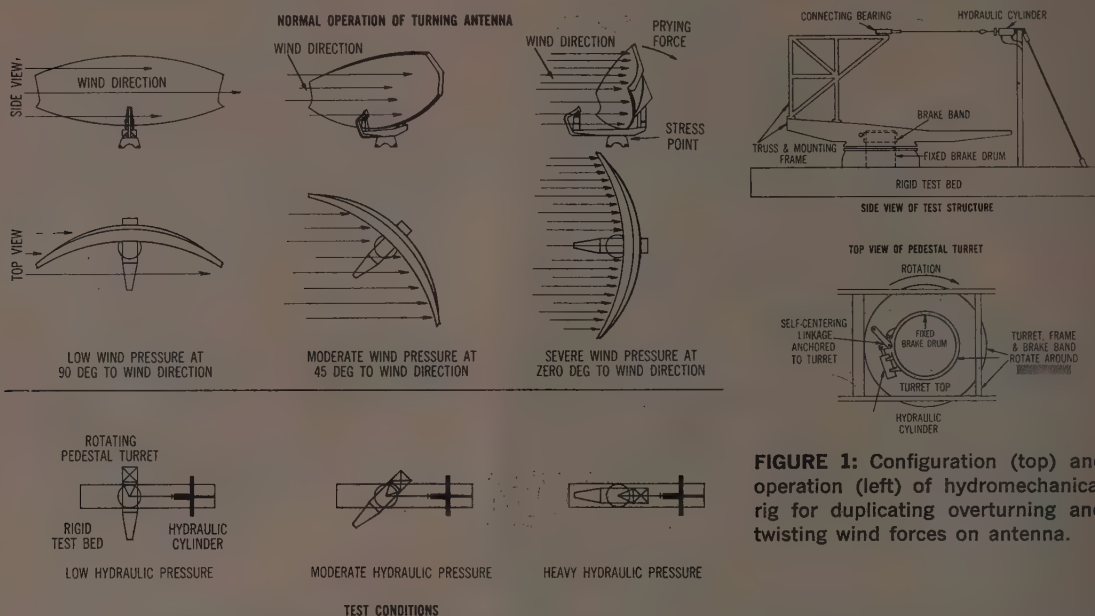


FIGURE 1: Configuration (top) and operation (left) of hydromechanical rig for duplicating overturning and twisting wind forces on antenna.

Antenna testing: Mechanical rig develops gale winds

There's more to testing a radar antenna than meets the eye. For instance, there's the question of how the turning mechanism for a 40-ft dish will stand up in high winds. One manufacturer had to develop a sizable hydromechanical test setup before he had the answer to that one.

THE design of a large radar antenna normally runs into more mechanical than electric problems. The major reason for this is the large forces imposed on the scan, tilt, and support mechanisms during operation.

A case in point is General Electric's FPS-33 long range search

radar. Its pedestal, designed and built by McKiernan-Terry Corp., Dover, N.J., supports and rotates a 40-ft parabolic-section dish and feed system. The dish, though screened, acts like a huge sail. It catches the wind and transmits its forces via mechanical linkages, which serve as a lever arm, to produce sheer and torsional moments against the pedestal turret and its bearings.

For example, a 65-knot wind broadside to the antenna results in an overturning moment of some 223,000 ft-lb—equivalent to a shear of 14,800 lb (Fig. 2). How to duplicate the effect of the wind for testing of the pedestal was a real problem for McKiernan-Terry engineers. The size of the monstrous assembly precluded wind tunnel experiments, and it was decided that mechanical means should be used.

Specifically, the pedestal had to be checked for overturning moments and torsional resistance in operation in winds up to 65 knots and for static loads in winds up to 94 knots. A hydromechanical rig provided the means for complete testing (Fig. 1).

The pedestal is mounted at one end of a rigid base, with its turret and tilt adapter feed arm support free to rotate 360 deg. Shear forces are generated by a tripod-mounted hydraulic cylinder placed at the opposite end of the test base and at the elevation of the center of wind pressure of the antenna that will ultimately be mounted on the pedestal.

The shear is transmitted through the cable connected to a bearing atop a welded truss attached to the antenna mounting bolt above the turret. The bearing is located at a point representing the correct antenna centroid of area.

Torsion loads are supplied by a brake. A brake band mounts on and rotates with the tilt adapter and acts against a water-cooled drum fixed to the test bed and extending vertically through the open center of the pedestal. Moving with the turret and against the

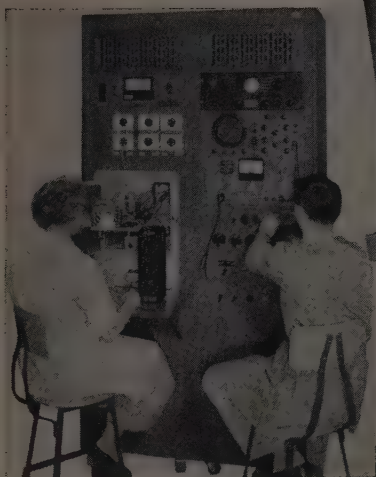
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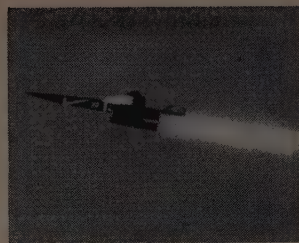
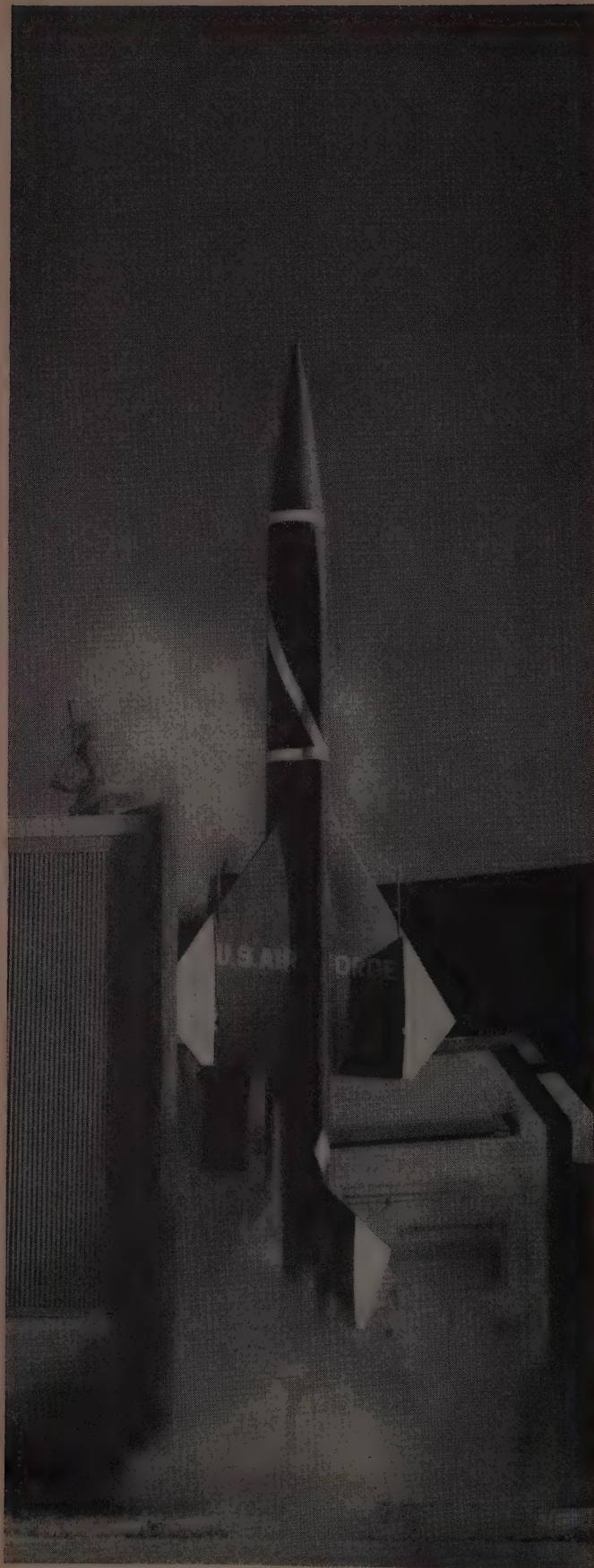
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Engineers For Advanced Projects:

Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Robert Burns, Personnel Manager, in confidence.

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45-9376



Supersonic BOMARC, America's longest-range air-defense missile

The Air Force's BOMARC is the most advanced, longest-range defense missile in the nation's arsenal.

Its range—200 to 250 miles—enables a single BOMARC base to protect an area of more than 200,000 square miles. One result is far fewer bases than would be required by short-range missiles. Another is effective defense, for BOMARCS destroy aerial attackers long before they reach U.S. borders. BOMARC's superior range means that bases can be located on remote, low-cost sites, instead of on expensive densely-populated land adjacent to major cities. In addition, it can be maintained by minimum crews and be fired automatically.

Single BOMARCS can seek out and intercept individual or multiple targets—either aircraft or missiles. They can be fired in rapid-sequence salvos. Armed with a nuclear warhead, a single BOMARC can destroy an entire formation of attackers.

BOMARC has great growth potential. Its range is being extended to more than 400 miles, which will enable one BOMARC base to protect more than 500,000 square miles. BOMARC can be developed to cope with intercontinental ballistic missiles.

The BOMARC system has been proved out in exhaustive tests, and the first base—at Eglin Air Force Base, Florida—is already operational. Other bases are nearing completion. BOMARC, in addition, has been chosen by the Canadian Government as its principal air-defense weapon.

BOEING BOMARC



ANTENNA TESTING . . .

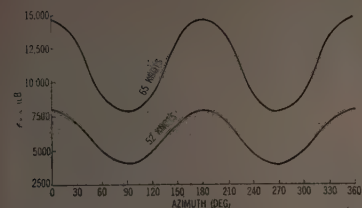
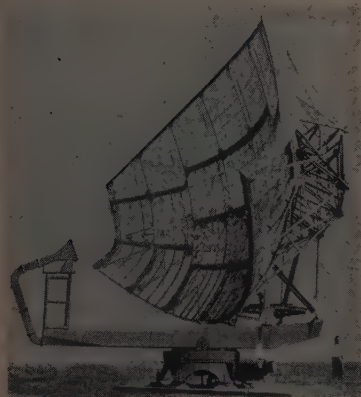


FIGURE 2: Wind load diagram for 360 deg of antenna rotation.



GE FPS-33 long range search radar has 40-ft dish that acts like a huge "sail" in high winds, must have a sturdy pedestal.

fixed drum, it produces the torsional resistance.

A hydraulic power unit supplies the necessary forces to both brake and overturning cylinder. Hydraulic pressures to both cylinders are regulated by cam-driven valves to simulate the cyclic wind effects as the antenna rotates.

Gages in the shear hydraulic cylinder lines monitor overturn-in moments. Torque loads exerted through the brake are measured on a recording watt-hour meter in the pedestal drive motor circuit.—JH

Atlas Guidance

Mod III ground guidance computer built by Burroughs for the Atlas was accepted by USAF. More sophisticated than previous computers, it has all basic circuitry in hermetically sealed modules.

New contracts for ground guidance equipment brought total of Burroughs' Atlas business to over \$68 million.

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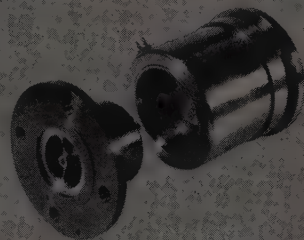
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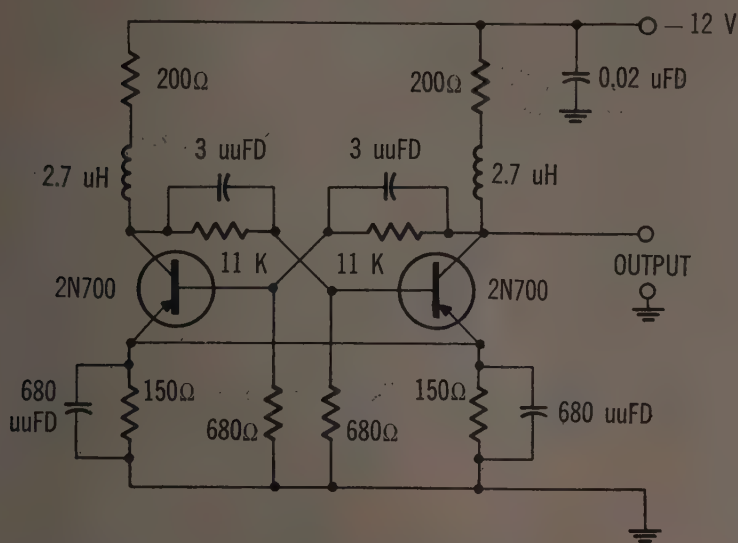
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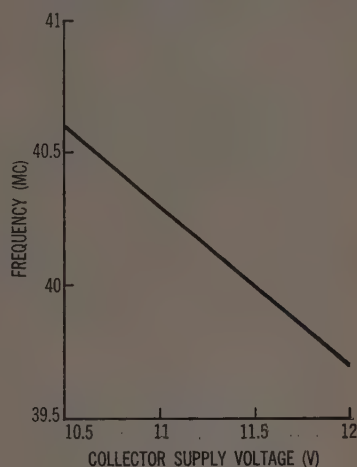
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FORTY-MC multivibrator using two mesa transistors.



OPERATING frequency of multivibrator using mesa transistors decreases with increasing supply voltage.

Astable multivibrator uses mesa transistors

Called "the most-needed device in military electronics" by Motorola, the mesa transistor has a bright future in space/aero systems. It was developed by Bell Telephone Labs for the Signal Corps. Motorola is producing two types of germanium mesas and Texas Instruments a silicon mesa.

by **D. G. Paterson**, Applications Dept.
Semiconductor Products Div., Motorola Inc.¹

SOME of the possibilities of the mesa transistor are shown by a simple astable multivibrator² designed and built by Motorola. Using Type 2N700 transistors, the circuit has operated satisfactorily in the

40-mc range from a collector supply of 12 V with a battery drain of about three ma.

The output waveform of 0.5 V peak to peak was sufficient to drive a Hewlett-Packard 524B frequency counter. The operating frequency decreased with increasing supply voltage (see Graph). Short term frequency stability was within 0.001 per cent for a fixed supply voltage.

It's an accepted fact that physical parameters leading to high frequency operation also yield high power capabilities in properly designed transistors. These capabilities have been achieved with the mesa construction, as well as the added advantage of subminiature size.

All but one part of the mesa structure is rigidly attached to the header providing shock and vibration resistance up to 50,000 G. As a result of very heavy impurity concentrations in the emitter and base regions, operation over a wider temperature range than with other germanium transistors is possible.

To be first used in HF through UHF

First uses of the mesa will come in the HF through UHF parts of the spectrum. However, the practical limit for this type transistor actually is around 10,000 mc. The power potential of the mesa is 10-30 W at frequencies up to 200 mc.

Another decided advantage of the mesa is that it is less susceptible to nuclear radiation than any other known transistor types. This is because the mesa:

- has extremely thin emitter and base layers;

more on page 154

(1) Semiconductor Products Div., Motorola Inc., 5005 E. McDowell Rd., Phoenix, Arizona.
(2) An "astable" multivibrator has two quasi-stable states and can switch from one to the other.

THE REQUIREMENT:

A leading missile prime contractor required complete in-plant testing consoles for check-out and servicing missile and missile power package hydraulic systems § providing a means of charging the missile nitrogen accumulators § checking servo valve action and monitoring position potentiometers of flight controls.

THE EQUIPMENT:

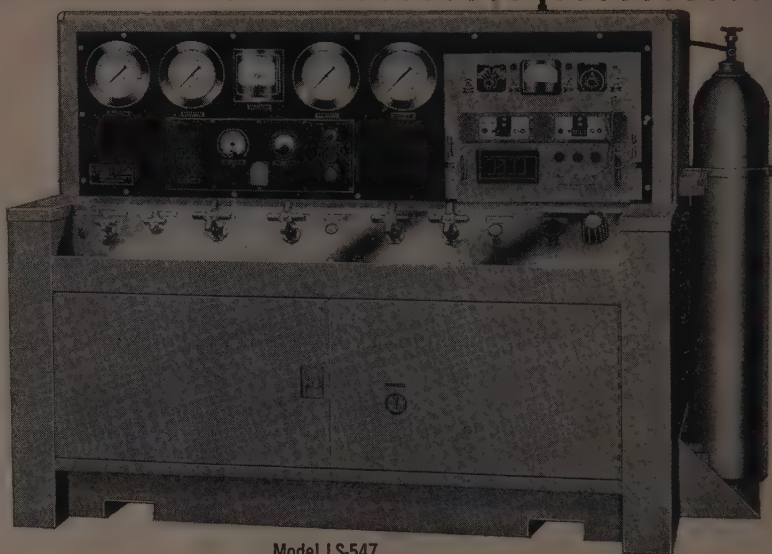
The Sun Model LS-547, Missile System Test Stand, meets all the requirements by incorporating separately controlled and instrumented hydraulic, nitrogen charging and electrical monitoring systems. Compactness — accuracy of check-out indications and speed and ease of operation are but a few of the unique design features of this unit.

THE BUILDER:

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Accumulator	15 cu. in./min
Charging System	at 2000 psig
Servo Valve Control	+ 12 to - 12 ma DC, variable
Position Potentiometer Tester Instrumentation	20 to 30 VDC regulated Fluid and Nitrogen Pressure gages, Fluid Flow Rate Indicator, Dual range Milli- ammeter, Digital Voltmeter



Model LS-547
Missile Systems Test Stand

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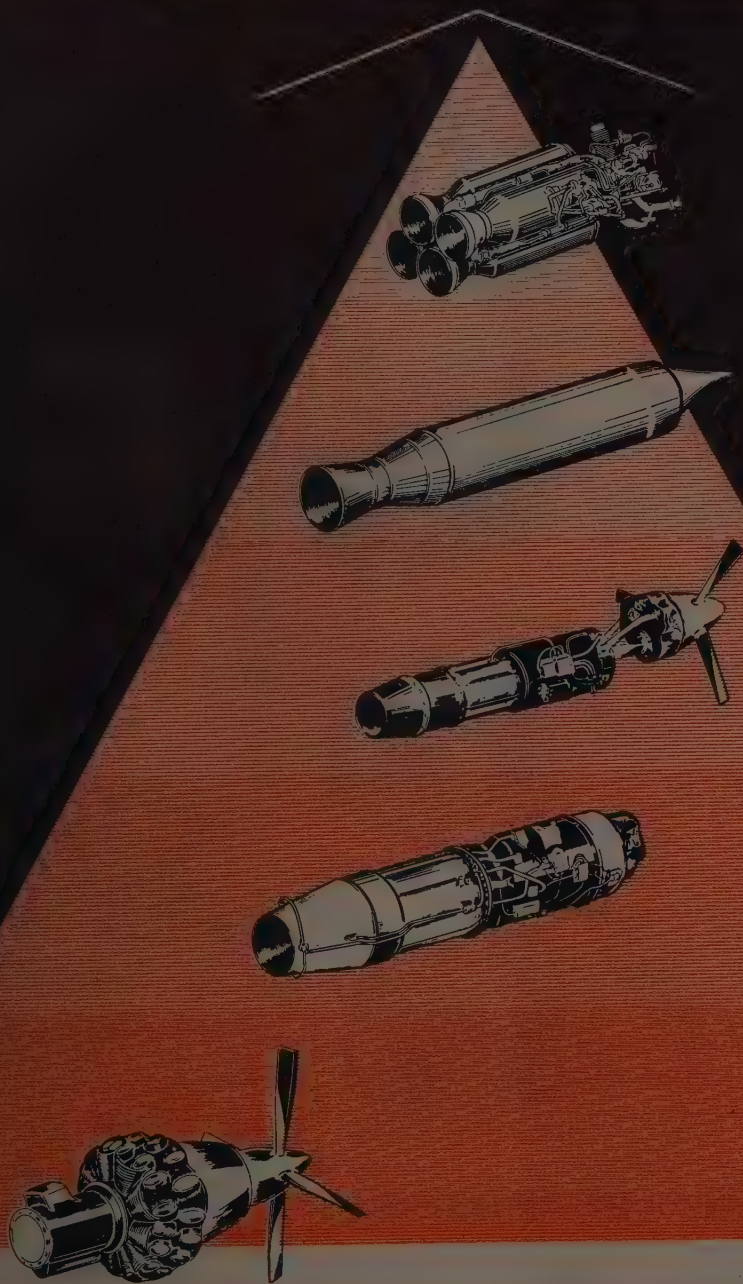
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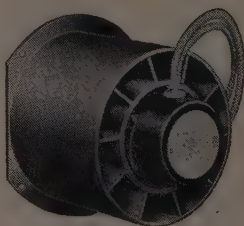
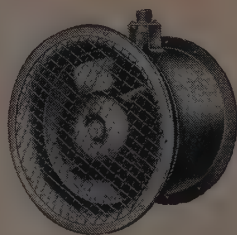
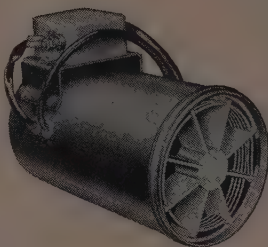
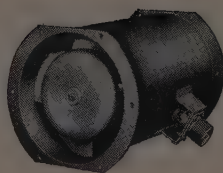
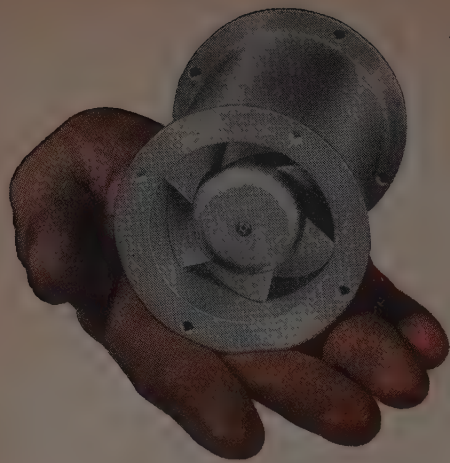


Bendix* has long been a leader in supplying controls and fuel systems for all types of aircraft engines. Today, Bendix is proving to be a natural for new challenges in related missile fields—on ram jets, rockets, nuclear power, and other advanced propulsion systems. So, when it comes to controls, remember that Bendix has the background—and is anxious to share it in solving your problems.

*REG. U.S. PAT. OFF.

BENDIX PRODUCTS DIVISION **SOUTH BEND, IND.**





choose from 325 MODELS OF JOY BLOWERS...

OVER 325 MODELS with 1300 designs available to meet your requirements... from 1/500th hp up... efficiency ratings up to 86%... pressures as high as 70" WG.

MEET MILITARY SPECS... accepted for airborne and ground installations by RCA, Boeing, Douglas, Motorola, Lockheed, Raytheon and many others.

VANEAXIAL DESIGN... motor mounted inside the fan... provides more air more efficiently than any other type fan.

RUGGED... because of simple design... vibration free, the outer casing, the vanes, and motor mounts are cast in one piece.

SPECIAL DESIGNS... We can furnish project engineers with any specially engineered fan to meet the toughest requirements and the tightest project deadlines.

WANT PROOF? Write Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pennsylvania.

WSW 1 7378-270

JOY

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



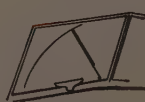
ELECTRONIC
COOLING



MISSILES
AND GSE



CABIN
VENTILATION



DEFOGGING
DE-ICING

Write in No. 248 on Reader Service Card at start of Product Review Section

MESA TRANSISTORS

Typical Electric Characteristics of Type 2N700 Germanium Mesa Transistor*

Collector cutoff current

($V_{CB} = -12$ V,
 $I_E = 0$)

1 μ a (10 μ a max.)

Emitter cutoff current

($V_{EB} = -0.5$ V, $I_C = 0$)

1 μ a

Max. frequency of oscillation

($V_{CB} = -6$ V, $I_C = 2$ ma)

600 mc

Power gain

($V_{CB} = -6$ V, $I_C = 2$ ma,
 $f = 200$ mc)

12 db

Small signal current gain

($V_{CB} = -6$ V, $I_C = 2$ ma,
 $f = 1$ kc)

10

Output capacitance

($V_{CB} = -6$ V, $I_E = 0$)

0.08 μ uf

Noise figure

($V_{CB} = -6$ V, $I_C = 2$ ma,
 $f = 200$ mc)

9 db

Base connection resistance

($V_{CB} = -6$ V, $I_C = 2$ ma,
 $f = 200$ mc)

50 ohms

*At 25 deg C.



SMALL SIZE of milliwatt mesa transistor should make it very desirable for microminiature circuits. Germanium slab used in the fabrication of this device is only about 0.025 in. square.

- is insensitive to damage to whole and electron lifetime (lifetime can be cut to around 10^{-8} or 10^{-9} seconds before there are any serious effects);

- only very large changes induced by nuclear radiation in the effective impurity concentration affect the transistor's performance. Write in No. 69 on Reader-Service Card for more information.—End

February 1959
(good until 4/15/59)

Employment Inquiry Form

(Not an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising in this issue.

To use this Form, follow these simple steps:

- (1) Tear out this page.
- (2) Check off the organization(s) listed below whose employment offers are of interest to you.
- (3) Turn to the back page of this Form and answer the questions on it.
- (4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.

SPACE/AERONAUTICS

205 East 42nd St.

New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

- | | |
|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| <input type="checkbox"/> AiResearch Mfg. Co. 194 | <input type="checkbox"/> National Aeronautics & Space Administrations 206 |
| <input type="checkbox"/> Avco Mfg. Co. 9 | <input type="checkbox"/> North American Aviation Autonetics Div. 157 |
| <input type="checkbox"/> Bendix Aviation Corp.; York Div. 162 | <input type="checkbox"/> Los Angeles Div. 159 |
| <input type="checkbox"/> Burroughs Corp. 164 | <input type="checkbox"/> Rocketdyne Div. 163 |
| <input type="checkbox"/> Cornell Aeronautical Laboratory, Inc. 38 | <input type="checkbox"/> Radiation, Inc. 164 |
| <input type="checkbox"/> General Electric Co. Light Military Electronics Dept. 165, 166 | <input type="checkbox"/> Republic Aviation Corp. 158 |
| <input type="checkbox"/> Missile & Space Vehicle Dept. 163 | <input type="checkbox"/> Rohr Aircraft Corp. 162 |
| <input type="checkbox"/> Lockheed Aircraft Corp. 161 | |

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations' just note its name and the page number of its advertisement in this space): _____

NOTE: If you have an immediate interest in any specific employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

February 1959
(good until 4/15/59)

CONFIDENTIAL

Employment Inquiry Form

(Not an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked—e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

AGE U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen?

Name:

Home Address:

Home Telephone:

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.

It's great to be proud of the place you work

A MAN misses a lot if his job means only a pay-check. He ought to be excited about the work he's doing. He ought to feel proud of his company—of its past achievements, its current projects, its future.

That's the way our engineers and scientists feel at Autonetics. They're young men. Most of them got their BS since 1948. In ten memorable years they have made their company a leader in *electronics* and *electromechanics*.

Today there is room for engineers and scientists who want to share the unusual creative problems that lie ahead—in inertial navigation, digital computers, armament control, flight control, and a host of special military and commercial products.

If you'd like to join Autonetics, please send your resume to Mr. D. B. Benning, 9150 East Imperial Highway, Downey, California.

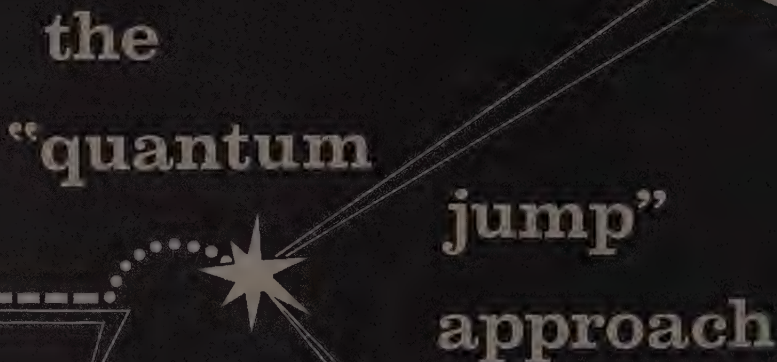
Autonetics 

A DIVISION OF NORTH AMERICAN AVIATION, INC.
Downey, California



Among the achievements of Autonetics' young men: the first successful airborne all-inertial navigation system... first navigation system accurate enough to guide the USS Nautilus and Skate on their historic voyages beneath Arctic ice... first successful automatic star tracking by an inertial navigation system during daylight flight... first completely maneuverable, inertially stabilized gyro platform... first successful completely automatic landing system for supersonic missiles and aircraft... first transistorized portable digital computer with "big computer" capabilities.

the "quantum jump" approach



NOT (-----) STEP-BY-STEP TRANSITION

How Republic's Engineers & Scientists Attack Today's Missile, Aircraft and Space Problems

There's something in the environment at Republic Aviation that fires the imagination and sharpens the logical faculties.

You find it, at its quintessence, within the research groups, whose members have recently come up with a feasible design for a "Magnetic Pinch Plasma Engine" to operate in space. A design utilizing a novel application of basic knowledge in the field of magneto-hydrodynamics.

The same spirit of bold inquiry, of looking beyond the

immediate, conventional solution of a problem for new and better answers, permeates the entire professional staff. You'll find it in development engineers working on new missiles for new missions... in experimental engineers studying the behavior of a prototype aircraft. You'll find it in the metallurgical and electronics labs.

THE RESULT - "quantum-jump" advances in many technologies vital to the conquest of upper atmosphere and space flight.

Engineers and Scientists who share Republic's views on Creative Problem-Solving are invited to discuss opportunities now open in the following areas:

THERMO, AERODYNAMICS

Theoretical Gasdynamics • Hyper-Velocity Studies • Astronautics Precision Trajectories • Airplane/Missile Performance • Air Load and Aeroelasticity • Stability and Controls • Flutter & Vibration • Vehicle Dynamics & System Designs • High Altitude Atmosphere Physics • Advanced Propulsion • Engineer Performance • Re-entry Heat Transfer • Supersonic/Hypersonic Wind Tunnels • Shock Tunnel • Plasma Tunnel • Magneto-Hydrodynamics • Ground Support Equipment

ELECTRONICS

Inertial Guidance • Inertial Navigation • Digital Computer Development • Radar Design • Systems Engineering • Information Theory

• Telemetry-SSB Technique • Doppler Radar • Countermeasures • Radio Altimeters • Radome & Antenna Design • Microwave Circuitry & Components • Receiver & Transmitter Design • Airborne Navigational Systems • Missile Checkout Systems • Missile Arming & Fusing • Jamming & Anti-Jamming • Miniaturization-Transistorization • Ranging Systems • Propagation Studies • Ground Support Equipment

PLASMA PROPULSION

Plasma Physics • Gaseous Electronics • Hypersonics and Shock Phenomena • Magneto-Hydrodynamics • Physical Chemistry • Combustion and Detonation • Instrumentation • High Power Pulse Electronics

Send resume in complete confidence to:
Mr. George R. Hickman, Engineering Employment Manager

REPUBLIC AVIATION
Farmingdale, Long Island, New York

REPUBLIC AVIATION is investing \$35,000,000 in bold new R&D Program designed to arrive at Major Breakthroughs in Transition from Aeronautics to Astronautics.



Investigating

Employment

Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities — and in turn give your request immediate consideration.

Check the "Employment Inquiry" form for details.

work in the fields of the future at NAA



TEST EQUIPMENT ENGINEERS

If you've been looking for an opportunity to explore new engineering territory, the positions now open in our electronics test equipment group may be right down your alley.

We need engineers to do research and development based on an entirely new electronics test equipment philosophy. Briefly, the job involves design of test equipment and analysis of electronics designs submitted by vendors and subcontractors. This is one phase of our work on advanced weapon systems B-70 and F-108.

A BSEE, plus experience, can qualify you.

For more information please write to: Mr. P. B. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 15, Calif.

THE LOS ANGELES DIVISION OF

**NORTH
AMERICAN
AVIATION, INC.**



Operations Research

Mathematicians, Physicists and Engineers with experience or strong interest in Operations Research on large-scale automated systems will be interested in the major expansion program at System Development Corporation.

SDC's projects constitute one of the largest Operations Research efforts in the history of this growing field. The projects are concerned primarily with man-machine relationships in automated systems in a number of fields, including air operations. The application of new and advanced digital computer techniques is particularly important in optimizing these man-machine relationships.

Senior positions are among those open. Areas of activity include: Mathematics, System Analysis, Forecasts, Cost Analysis, Operational Gaming, Design Analysis, Performance Evaluation.

Those who have professional questions or desire additional information are invited to write Dr. William Karush, Head of the System Development Corporation Operations Research Group at 2424 Colorado Avenue, Santa Monica, California.

"Method for First-Stage Evaluation of Complex Man-Machine Systems"

A paper by I. M. Garfunkel and John E. Walsh of SDC's Operations Research Group is available upon request. Address inquiries to Dr. William Karush at System Development Corporation.



SYSTEM DEVELOPMENT CORPORATION

Santa Monica, California

(right) Part of giant capacitor bank used to fire "hotshot" tunnel. Bank is capable of 5 million kilowatt jolt.



(above) Lockheed's "hotshot" tunnel — only one in private industry.

(right) Research and Development facilities in the Stanford Industrial Park at Palo Alto, California, provide the latest in technical equipment.



EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY ... Thermodynamics

Lockheed capabilities in thermodynamics and gas dynamics are unsurpassed in private industry. Basic work is being performed on problems relating to missiles and spacecraft under simulated conditions of upper atmosphere and outer space. Studies include: boundary layer flow and heat transfer; cooling and insulation; thermodynamic instrumentation for flight test; design of rocket motor controls and nozzle structures; re-entry thermal protection; materials specification; and thermal environments of electronic, mechanical and hydraulic equipment. Also under study are new methods and improved techniques of thin film thermometry, measurements of dissociation and combination of nitric oxide and high-speed shock wave flows.

Equipment includes the fastest wind tunnel in industry, fired by 20 million kilowatts; a hydromagnetic tube which produces velocities of over Mach 250 and temperatures approaching 500,000°K; a "hotshot" tunnel for shock wave, gas and heat studies, capable of velocities of 16,500 mph and temperatures above 12,000°F; and a ballistic range on which projectiles are fired at speeds up to 20,000 ft/sec.

Scientists and engineers of outstanding talent and inquiring mind are invited to join us in the nation's most interesting and challenging basic research programs. Write: Research and Development Staff, Dept. B-16, 962 W: El Camino Real, Sunnyvale, California.

"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics." NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

Lockheed

MISSILE SYSTEMS DIVISION

SUNNYVALE, PALO ALTO, VAN NUYS,
SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA
ALAMOGORDO, NEW MEXICO



Engineers
see
the job
through
at Rohr.

Engineers at Rohr enjoy the special satisfaction of seeing their ideas take shape from plans straight through production.

No studies that get pigeon-holed . . . no projects that never get off the ground . . . but important engineering jobs that get into production right here at Rohr.

And, Rohr, today offers experienced engineers the opportunity and security reflected in a backlog figure of over a quarter-billion dollars — more than 60% of which is in commercial contracts.

Currently Rohr needs Design, Liaison, and Structures Engineers who have a background of achievement . . . and who desire a future with greater satisfaction and accomplishment.

If you qualify, please forward full resume at once to J. L. Hobel, Industrial Relations Mgr., Rohr Aircraft Corporation, Chula Vista, California. Dept. 6-B



ROHR
AIRCRAFT CORPORATION

Chula Vista and Riverside, California

Check Employment Inquiry Form Page 155

ENGINEERS:



The kind of work
you want in
**MISSILE
ELECTRONICS**



The kind of life
you want for
your family

GET *BOTH* AT
BENDIX YORK

**ELECTRONIC
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PHYSICISTS

MECHANICAL ENGINEERS

- Challenging opportunities in CIRCUIT DESIGN, PULSE & VIDEO CIRCUITRY, MICROWAVE, DIGITAL & ANALOG COMPUTERS, SEMI-CONDUCTORS, COMPONENT AND CIRCUIT RELIABILITY.

Interesting work on FUZING TECHNIQUES, BEACONS, SIMULATORS, SPECIAL TEST EQUIPMENT.

- Bendix York offers you the opportunity for rapid professional growth and advancement. Enjoy the small-company atmosphere of an expanding division of one of America's largest engineering and manufacturing corporations . . . And the way of life in and around York, Pennsylvania is ideal for the entire family. It combines the charm and grace of rural living with the many advantages of a dynamic and progressive community.

Let us hear from you!
Address replies to: Dept. S
PROFESSIONAL EMPLOYMENT

Bendix
AVIATION CORPORATION
York Division

York, Pennsylvania

"The way of work for you,
the way of life for your family!"

Check Employment Inquiry Form Page 155
SPACE/AERONAUTICS

Important Progress in Salient Fields of Interest in Missile and Space Technology Has Created Immediate Openings of High Professional Calibre

The Missile and Space Vehicle Department of General Electric—the department that designed and developed the first successful Intercontinental Ballistic Nose Cone—has made rapid progress in diverse areas of study pertinent to man's conquest of space. Expanding study programs are now under way that envisage new technologies applicable to missiles, satellites and manned space vehicles.

Immediate and exciting openings of high level exist for:

PHYSICISTS—

To investigate solid state phenomena, shock hydro-dynamics, shock-wave and heat transfer factors associated with hypersonic vehicles.

OPTICAL SPECIALISTS—

To design and develop interferometric, schlieren and periscopic devices for aerodynamics research and to consult on the use of optical devices in space navigation.

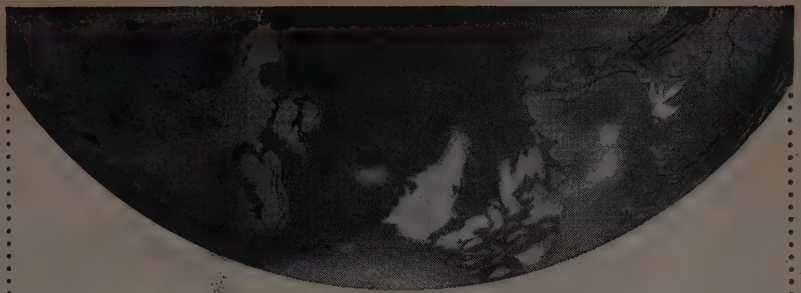
Major technical programs, carried on under long-term prime development contracts at the Missile and Space Vehicle Department are pursued in a climate of scientific curiosity under ideal laboratory conditions.

Please submit your qualifications in complete confidence to:

Mr. R. L. Eddy, Dept. 701-3
Professional Placement

GENERAL  ELECTRIC

Missile and Space Vehicle Dept.
3198 Chestnut St., Phila. 4, Pa.



Look Over the Challenge of Rocket Research in the Fields of Advanced Propulsion, Experimental Instrumentation, Research Design, Experimental Operations

The men we're looking for should have a good academic background and extensive industrial experience. They should be mature and adept in contact work with our outside vendors. We particularly need men who have the flexible outlook and the quick mind it takes to make design changes in the field.

Designers of Specialist Caliber. Extensive experience in the design of mechanical components, using a wide range of materials; capable of stress evaluation, with a general knowledge of heat transfer and fluid flow; good background in electronic control equipment, welding and brazing techniques, metallurgy, and precision machine shop practice.

Senior Research Engineer. Degree in electrical engineering or physics, with an electronics major or equivalent and at least four years of experience in servo design and analysis. His work will include: end-element research; study of design criteria regarding dynamic behavior of rocket engine systems; basic research in control system synthesis methods; investigation of various control methods.

Research Engineer. Degree in electrical engineering or physics, with an electronics major and at least one year in instrumentation or an allied field. He will be a research instrument engineer, responsible for creating complete instrumentation systems to derive theoretical and experimental knowledge from research on statistically tested rocket engines and other combustion devices. His ingenuity will constantly be challenged by such problems as measuring high frequency pressure and flow fluctuations, gas temperatures in excess of 5000° F, and various other parameters—including time, thrust, acceleration, displacement, and gas composition—by spectrographic means.

Rotating and Turbo-Machinery Specialists. These men should be senior research engineers with advanced degrees, no less than five years of experience, and a talent for supervising projects or units of engineers. Their work will involve applied and basic research on aerodynamics and fluid flow problems of advanced rocket engine turbo-machinery.

Senior Research Engineer. MS, ME, or PhD. Must be experienced in flow measurements of unconventional type. His work will involve research and analysis of flow measurements and the dynamics of flow problems.

Instrumentation Engineer. BS, MS, PhD in electrical engineering or physics. His experience should be in developing and using instrumentation on problems directly affecting test programs.

Please write to Mr. F.B. Jamieson, Engineering Personnel Dept., 6633 Canoga Avenue, Canoga Park, California.

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

FIRST WITH POWER FOR OUTER SPACE





ANOTHER NEW ROSTER OF OPPORTUNITIES APLENTY AT BURROUGHS

Again we are stepping up our aggressive research and development programs. These have already made us a \$300-million-a-year force in *advanced electronic and electro-mechanical information processing* for both commerce and defense. Here are just a few of the many exceptional career opportunities open right now for exceptional men:

CALIFORNIA at our ElectroData Division in Pasadena

Electronic Engineers with experience in areas such as logical design, computer components, circuit design, electronic packaging, sub-miniaturization, manufacturing costs and processes.

Electronic Data Processing Specialists with experience in areas such as applied programming, applied mathematics and technical sales consultation, etc.

For Details, write Mr. C. J. Blades, Manager, Professional Employment, Dept. 205A, Burroughs Corporation ElectroData Division, 460 Sierra Madre Villa, Pasadena, California.

PENNSYLVANIA at our Research Center near Philadelphia

Systems Engineers with specific experience in systems analysis and design of digital data processors. Should be trained in engineering, physics or mathematics. Graduate training desirable.

Mathematicians, computer-oriented, with particular experience in problem formulation, numerical analysis, and applied mathematics—in connection with formulation and design of computational procedures. Procedures involved in problems of guidance and air defense, trajectory calculations, logical design, sampled data systems, circuit analysis and more. Advanced degree in mathematics preferred.

For Details, write Mr. James Gilroy, Professional Placement Coordinator,

Dept. 205B, Burroughs Corporation Research Center, Paoli, Pennsylvania.

PENNSYLVANIA at our Military Field Service Division in Phila.

Field Engineers responsible for the direction of several field teams in installation and maintenance of digital computers and integrated data processing systems. Required BSEE, with extensive field service experience in military electronic equipment.

Site Engineers to attend formal lab and lecture training program of 16 weeks in electronic data processing equipment at full salary. Assignments after completion of formal program plus field training will involve direct supervision of a field team in installation and maintenance of data processing equipment. BSEE preferred, or equivalent experience. Must be willing to travel and relocate.

For Details write Mr. A. J. Bellace, Employment Supervisor, Burroughs Corporation Military Field Service Division, Dept. 205C, Burroughs Drive, Radnor, Pennsylvania.

MICHIGAN at our Burroughs Division in the Detroit Area

Experienced Electronic, electrical and mechanical engineers to work in many areas of research and development for information processing equipment applicable to commercial and military use.

For Details, write Mr. A. L. Suzio, Administrator, Corporate Placement Services, Dept. 205, Burroughs Corporation, Detroit 32, Michigan.



Burroughs Corporation

"NEW DIMENSIONS" / IN ELECTRONICS AND DATA PROCESSING SYSTEMS

Check Employment Inquiry Form Page 155

in the rough?



A snowstorm is a pretty big handicap even for a pro. Join Radiation, Inc. in Florida where you can play golf all winter long. The entire family will enjoy outdoor recreation and the efficient, open architecture of Florida homes.

We have many openings for challenging and rewarding work in electronic design and development. Radiation is well known in DATA PROCESSING, TELEMETRY, ANTENNAS, INSTRUMENTATION, and other areas of MISSILE ELECTRONICS. Our stable growth indicates a secure future with professional advancement for qualified electronic engineers with ideas and energy. Write today for complete details on opportunities available.

Technical Personnel Dept. 27.



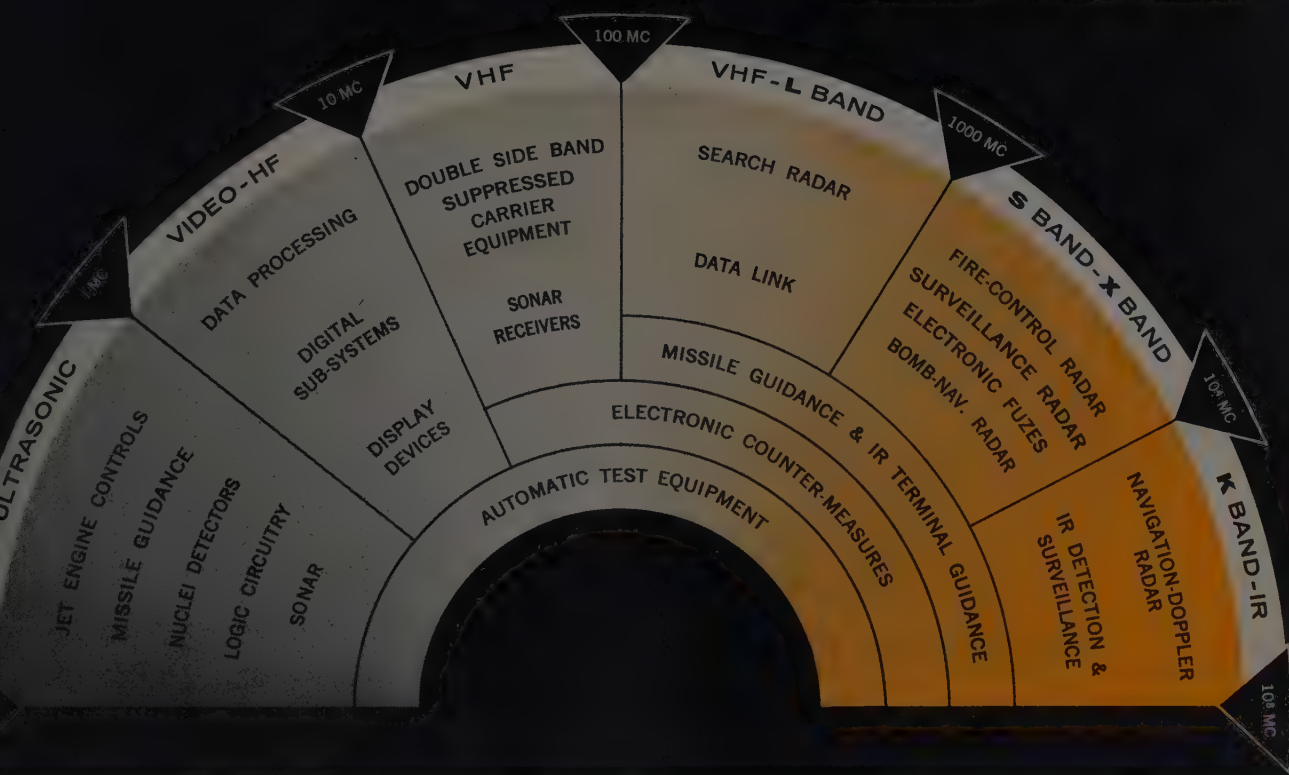
RADIATION, Inc.
MELBOURNE, FLORIDA

Check Employment Inquiry Form Page 155

IMPORTANT

In filling out "Employment Inquiry Form" be sure to print clearly. When you check more than one company, the form must be photostated so that each company receives a copy.

Check Employment Inquiry Form Page 155
SPACE/AERONAUTICS



Professional Challenge Awaits You At Any Point Along The RF Spectrum

At General Electric's Light Military Electronics Department

By designing across the entire electro-magnetic spectrum, Light Military displays unusual diversification — but *equally important*, it demonstrates a characteristic of high significance to

engineers seeking long-term futures — *stability*.

A unique combination of these two factors — diversity *and* stability — provides the formula for unusually rewarding careers at Light Military.

For details of the specific engineering challenge...and an important promise, turn to the reverse side of this page. ►

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Mr. Richard C. Kimm
General Electric Company
Light Military Electronics Department
French Road, Utica, New York

LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

A CHALLENGE

AND

A PROMISE

The Challenge is Diversity

When one organization offers consistent engineering challenge in areas ranging all the way from Audio through RF and Microwave regions, to IR—you can begin to visualize the stimulating professional climate that is generated and regenerated here.

It takes a versatile engineer who can move freely across his discipline, exposing himself to unfamiliar problems and exploring new ideas with colleagues in the advanced areas of electronics.

The Promise is Stability

The experienced engineer will recognize that long-term stability is implicit in Light Military's wide-ranging diversity. This characteristic is further enhanced by the large company resources of General Electric. Yet G. E.'s policy of decentralization sets the Department free to get the job done—with on-the-spot management to make vital decisions quickly and effectively.

AND FOR YOUR FAMILY Utica is a modern, growing city, located in New York State's famous Mohawk Valley. Close at hand are skiing, hunting, hockey, fishing, swimming, boating, golf, tennis. City and suburban housing of all types, well-staffed schools and excellent stores round out a picture of full family living in an invigorating 4-seasons climate.

INVESTIGATE THE CAREER OPPORTUNITIES that exist for you at Light Military right now. To make your initial contact most convenient, use the postcard below. Simply fill it out, and mail today ▼

LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL  ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

15-MB

Dear Mr. Kimm:

I am interested in professional career opportunities at Light Military.

Name _____

Home Address _____

City _____ Zone _____ State _____

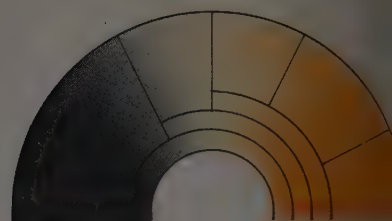
Phone _____

Degree (s) _____

Year (s) Received _____

I am particularly interested in the following technical areas: _____

(U.S. citizenship required)



A Record of Continuous Engineering Achievement Underscores the Potential for Rapid Professional Growth

Recent projects that have won recognition for both the Department and its engineers include:

POLARIS FIRE CONTROL & GUIDANCE COMPUTER ELECTRONICS

It is one of the functions of the fire control computer electronics to keep the Polaris missile—now under development—always battle-ready, with a freshly calculated trajectory toward its pre-programmed target. The computer electronics *operate continuously*, constantly plotting the submarine's changing position, taking into account all parameters of speed, direction, angular disturbance, compass references, etc., and cranking new trajectory equations into the memory circuits of Polaris' guidance computer electronics.

AIRBORNE COMBAT INFORMATION CENTER

This integrated system covers functions previously performed from land-based or ship-based CIC's. After target position, heading and speed have been established by the system's powerful search radar, intercept courses are plotted and radioed directly to the appropriate defense forces.

AIRBORNE ECM Although details of the equipment are still classified, Light Military's highly miniaturized system represents a considerable advance in flexibility and reliability over earlier systems. A new program for development of an intelligent Airborne ECM Intercept System—*not only capable of detecting, but defeating enemy radar devices*—is now underway.

AIRBORNE NAVIGATION SYSTEM

This 150-pound system is of the Doppler/Inertial/Computer type, and does not depend upon any form of ground information or control.

MAJOR PRODUCT GROUPINGS AT LIGHT MILITARY INCLUDE:

Airborne Data Link • Airborne Early Warning and Control Systems • Airborne Electronic Warfare and Electronic Defense Systems • Airborne Fire Control and Bombing Equipment • Airborne Navigation Systems and Equipments • Aircraft Defensive Armament Systems • Automatic Test Equipment • Communications Systems • Digital and Analog Computers • Missile Systems and Missile-Borne Guidance and Control Equipment • Terminal Control Systems and Fuzes • Undersea Warfare Systems

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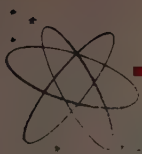


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product index to advertising



THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements on which complete information was not available at the closing date (January 5) are not necessarily covered by these indexes.

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READY AT EVERY STEP-UP



FAFNIR AIRCRAFT BEARINGS

THE INTRODUCTION of a new, special-precision M SERIES of ball bearings demonstrates how Fafnir has kept in step with aircraft progress since the "box kite" era. This new series, used in power operated aircraft control systems, meets the ever more exacting demands for instantaneous and accurate response. Its special precision quality, resulting in low torque, assures greater sensitivity. Closer tolerances eliminate backlash. **FAFNIR** Special Precision Series Control Bearings are designed to be dimensionally identical to and interchangeable with their counterparts in the Fafnir AN Standard Series covered by MIL-B-7949. Boundary dimensions and eccentricities, however, are held to closer tolerances. Bore and outside diameter variations are decreased and radial play reduced in value. **FAFNIR** Each stage in aircraft development is represented by Fafnir bearing contributions. The M SERIES is a current example.



FAFNIR
AIRCRAFT BEARINGS

For complete details on the new M SERIES write The Fafnir Bearing Company, New Britain, Connecticut.

FIRST AT THE TURNING POINTS IN AIRCRAFT DESIGN
Write in No. 263 on Reader Service Card at start of Product Review Section

SPACE/AERONAUTICS

**IMPROVED
CHARACTERISTICS**

**...OF
SPECIAL
INTEREST
TO AVIATION
ENGINEERS**

DELCO HIGH POWER TRANSISTORS



UNEXCELLED FOR LIGHT WEIGHT, SMALL SIZE, EFFICIENCY, RELIABILITY, SWITCHING

TYPICAL CHARACTERISTICS AT 25°C.

	2N1100	2N1099	2N174A	2N174	2N173	2N278	2N277	2N443	2N442	2N441
Maximum Collector Current	15	15	15	15	15	15	15	15	15	15 amps
Maximum Collector Voltage (Emitter Open)	100	80	80	80	60	50	40	60	50	40 volts
Saturation Resistance	.02	.02	.02	.02	.03	.03	.03	.03	.03	.03 ohms
Thermal Gradient (Max.) (Junction to Mounting Base)	.8	.8	.8	.8	.8	1.0	1.0	1.0	1.0	1.0 °C/watt
Base Current I_B ($V_{EC}=2$ volts, $I_C=5$ amps)	135	100	135	135	100	100	100	150	150	150 ma
Collector to Emitter Voltage (Min.) Shorted Base ($I_C=.3$ amps)	80	70	70	70	50	45	40	50	45	40 volts
Collector to Emitter Voltage Open Base ($I_C=.3$ amps)	70	60	60	60	50	45	40	55	45	40 volts

*Designed to meet MIL-T-19500/13A (Jan) 8 January 1958

†Formerly DT100

‡Formerly DT80

Check your requirements against the *new, improved* characteristics of Delco High Power transistors. You will find improved collector-to-emitter voltage . . . higher maximum current ratings—15 amperes, and extremely low saturation resistance. Also, note the new solid pin terminal design.

And of special importance to you is the fact that diode voltage ratings are at the maximum rated temperature (95°C.) and voltage.

Write today for engineering data on the *new, improved* characteristics of *all* Delco High Power transistors.

DELCO RADIO

Division of General Motors • Kokomo, Indiana

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

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CLASSIFIED

Fast Service and 30 day Approval on all Aviation, Aero. Engrg. & Space books. Avia. Pub. Serv. Box 566, Ypsilanti, Mich.

BENDIX SR RACK AND PANEL CONNECTOR

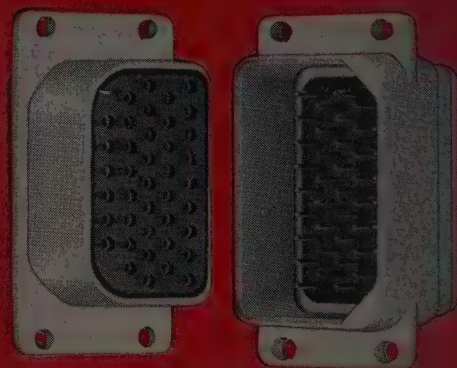
*with outstanding resistance
to vibration*

The Bendix type SR rack and panel electrical connector provides exceptional resistance to vibration. The low engagement force gives it a decided advantage over existing connectors of this type.

Adding to the efficiency of this rack and panel connector is the performance-proven Bendix "clip-type" closed entry socket. Insert patterns are available to mate with existing equipment in the field.

Available in general duty, pressurized or potted types, each with temperature range of -67°F to +257°F.

Here, indeed, is another outstanding Bendix product that should be your first choice in rack and panel connectors.



FEATURES:

Resilient Insert • Solid Shell Construction • Low Engagement Forces • Closed Entry Sockets • Positive Contact Alignment Contacts—heavily gold plated Cadmium Plate—clear irridite finish • Easily Pressurized to latest MIL Specifications.

SCINTILLA DIVISION

SIDNEY, NEW YORK



Export Sales and Service: Bendix International Div., 205 E. 42nd St., New York 17, N. Y.

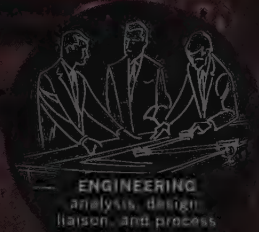
Canadian Affiliates: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec.

Factory Branch Offices: Burbank, Calif.; Orlando, Florida; Chicago, Illinois; Teaneck, New Jersey; Dallas, Texas; Seattle, Washington; Washington, D. C.

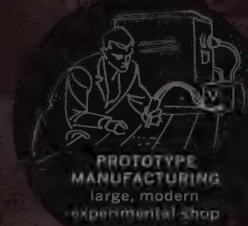
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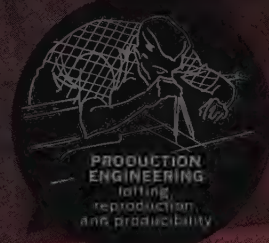
600,000 SQUARE FEET... TO YOUR PRODUCTION CAPACITY...



ENGINEERING
analysis, design,
liaison, and process



**PROTOTYPE
MANUFACTURING**
large, modern
experimental shop



**PRODUCTION
ENGINEERING**
tooling,
reproduction,
and productivity

Prime contractors looking for major subcontract capability in missiles, rocket engines, ordnance, or electronics will find it at Rheem. With more than 600,000 square feet at Downey, California, the Rheem Defense and Technical Products Division offers a unique combination of experience and facilities that is unmatched in the West.

If you require unusual skills in critical welding or machining operations, be sure to consult Rheem. Rheem will assume the complete responsibility for system, subsystem, or component production, from engineering through manufacturing . . . whatever best suits your requirements. You will be impressed by the "package contract" capability that is available to you.

For the full details on Rheem availability for subcontract assignment, write to Dept. SA-712-1.



TOOLING
tool design and
manufacture

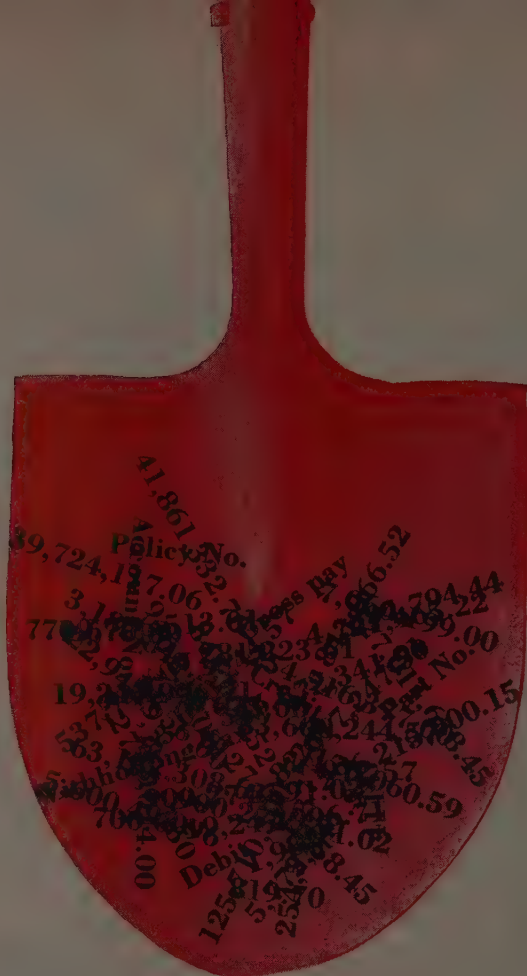


MANUFACTURING
systems, assemblies,
and components



RHEEM MANUFACTURING COMPANY
Defense and Technical Products Division
11711 woodruff avenue, downey, california

PULSION & MISSILE SYSTEMS • ELECTRONICS • DRONES • ORDNANCE • PRESSURE VESSELS • RESEARCH



does both jobs equally well - Burroughs 205 Computer



From the sequential solution of long scientific problems to the mass processing of business data, the versatile Burroughs 205 electronic data processing system is ideally suited to a wide range of applications. Top capacity and speed in the medium price class, complete choice of input-output media, vast external magnetic tape storage. At work in many varied industries, the 205 has proven its superior dollar-for-dollar value. Its flexibility lets you grow into a larger Burroughs system as your needs increase. Burroughs extensive support program provides on-the-spot technical assistance for an advanced and complete line of data processing systems...all currently in production. Write for 205 brochure. ElectroData Division, Pasadena, California.



Burroughs Corporation

"NEW DIMENSIONS/in electronics and data processing systems"



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equipment briefs



ACOUSTIC NOISE GENERATOR

AN ELECTROMECHANICAL loudspeaker producing up to 166 db of random noise has been developed by Avco Div., 201 Lowell St., Wilmington, Mass., for acoustic noise testing of missile components. Up to 170 db can be generated at single or discrete frequencies from 20 to 2400 cps.

A progressive wave tube is used

with the acoustic noise generator for testing small parts or subassemblies. For large assemblies of parts, a reverberant chamber is used instead of the tube. The noise produced by the generator reverberates inside the chamber and bounces off the walls to excite the parts under test. Write in No. 64 on Reader-Service Card for more information.



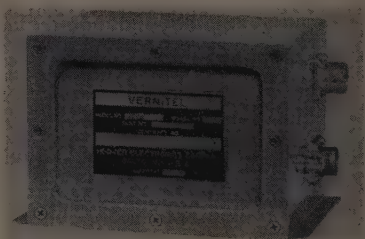
ROTATING PARACHUTE

A PARACHUTE that produces aerodynamic drag has been announced by Pioneer Parachute Co., Inc., Manchester, Conn. It is a rotating 'chute that substitutes four sections of cloth, or "blades," for the standard circular canopy.

The corners of the trilateral "blades" are attached to nylon suspension lines drawn together below the 'chute at a swivel. The blades of cloth rotating about this swivel create a vortex ring, or doughnut of air, which in effect increases the total drag area.

The vortex ring parachute is re-

ported to have excellent stability, low shock effect on opening, and virtually no oscillation of glide characteristics. According to the makers, cargo dropped in "sticks" will land in "sticks." The rate of descent is said to be comparable to that of a conventional 'chute with 60 per cent more cloth area. Write in No. 65 on Reader-Service Card for more information.



BETTER FM-FM TELEMETER ACCURACY

A TECHNIQUE developed by Hoover Electronics Co., Timonium, Md., allows the transmission of high accuracy data over standard FM-FM telemetry systems. It is based on the "Vernitel," a single unit that is readily added to existing FM-FM transmission systems.

The Vernitel consists of a special quantizer and a differential amplifier. It continuously separates an input voltage into 16 discrete levels and provides a vernier, or residue, voltage representing the analog scale between quantized increments. Each of these voltages is used to control a standard FM subcarrier oscillator.

Information inputs may be derived from transducers or signal conditioners with 0-5 V output. Inputs may be commutated at standard IRIG rates. Vernitel provides each SCO with a 0-5 V signal for full modulation. By interpolation at the receiver, the output of two standard discriminators may be added. The resulting signal accuracy is improved by a factor of 16 over the nominal value. Write in No. 67 on Reader-Service Card for more information.

more on page 176

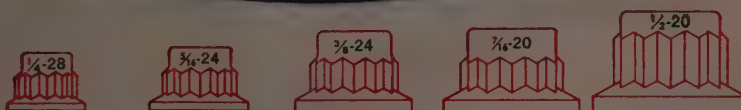
NEW *light-weight* 220,000 psi

ESNA SELF-LOCKING NUT*

for advanced
structural design...
high-tensile bolting



WEIGHT COMPARISON TABLE
in lbs. per 100 pieces



all drawings are shown in actual size

ESNA LH3393 (220,000 psi)	.44	.77	1.20	1.69	2.55
COMPETITIVE Lightest Nut (180,000 psi)	.60	1.00	1.50	2.15	2.82
COMPETITIVE Lightest Nut (220,000 psi)	.95	1.62	2.75	4.25	6.00

tomorrow's hypersonic airframes must withstand flight stresses and related vibration conditions that would have seemed insurmountable even five years ago. Yet to achieve these speeds these aircraft will have to utilize lighter-weight structural components than their subsonic predecessors. ESNA Type LH3393 double hex, external wrenching nut now offers the designer of tomorrow's airframes and missiles a structural fastener with the highest strength-to-weight ratio currently available self-locking nut. Design refinements embodied in the LH3393 series constantly develop the full fatigue strength of 220,000 psi high strength bolts... yet these nuts are from 10% to 33% lighter, size for size, than even the lightest 180,000 psi knut.

Additional weight savings are made possible by the smaller envelope dimensions of these new parts, since reduction of wrench clearance requirements permits reductions in the size of other structural components.

LH3393 series nuts are cold-formed from alloy steel, processed with the manufacturing skills and protected by the rigid quality control established during ESNA's 30 years of experience in supplying dependable aircraft quality fasteners. The same military approved, ELLIP-TITE locking device used on ESNA's complete line of NAS parts, assures reliable vibration proof self-locking performance at temperatures up to 550°F.

For specific dimensional, design and test data on ESNA's new, lightweight, 220,000 psi nut—Type LH3393, write to Dept. S23-250 Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.



**ELASTIC STOP NUT
CORPORATION OF AMERICA**

* U.S. Patent No. 2,588,372

Write in No. 268 on Reader Service Card at start of Product Review Section

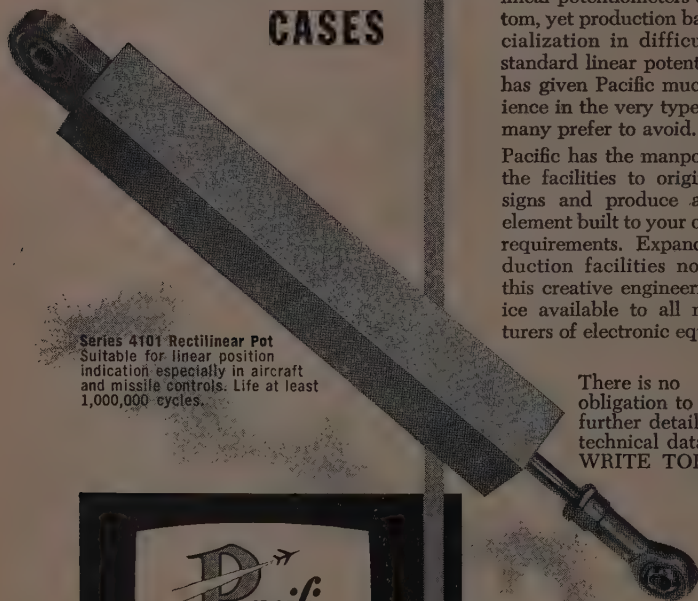
Pacific



SPECIALISTS IN DIFFICULT, NON-STANDARD LINEAR POTENTIOMETER DESIGNS

Series 4103 Circular Pots, as shown above — are particularly suited to telemetering, control systems and computers. Furnished single or ganged up to 5 units. Life at least 1,000,000 cycles.

Cuts custom design costs with 4 BASIC POTENTIOMETER CASES



Series 4101 Rectilinear Pot Suitable for linear position indication especially in aircraft and missile controls. Life at least 1,000,000 cycles.

Pacific Scientific can design and build custom linear potentiometers to your most critical requirements . . . yet save you time and money by incorporating them into any one of four standard cases!

You are, of course, not limited to these 4 cases — for Pacific has the ability to design and produce precision wire-wound linear potentiometers on a custom, yet production basis. Specialization in difficult, non-standard linear potentiometers has given Pacific much experience in the very type of work many prefer to avoid.

Pacific has the manpower and the facilities to originate designs and produce a special element built to your own rigid requirements. Expanded production facilities now make this creative engineering service available to all manufacturers of electronic equipment.

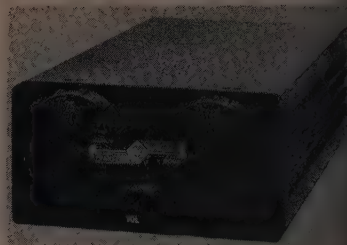
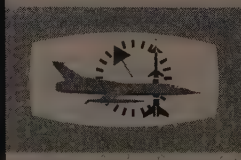
There is no obligation to obtain further details — and technical data sheets. **WRITE TODAY!**

Creative Manufacturing and Development in Aircraft Safety



PACIFIC SCIENTIFIC COMPANY
P.O. Box 22019, Los Angeles 22, California

San Francisco • Seattle
Arlington, Texas • San Diego
Representatives: Eastern U.S.—Aero Eng. Co.
Canada—Garrett Mfg. Corp.



LOW COST VHF SET

AN ALL-CHANNEL VHF airborne communications unit selling for under \$1000 is being made by National Aeronautical Corp., Ft. Washington, Pa. The Narco Mark V is made up of a 90-channel, crystal-controlled receiver for all frequencies between 108 and 126.9 mc and a 190-channel, crystal-controlled receiver for all frequencies between 108 and 126.9 mc (ILS/VOR navigation and communications). Complete with separate transistor-toroid power supply it measures $6\frac{1}{2} \times 3 \times 12$ in. Total weight is only $9\frac{1}{2}$ lb.

The large numbers on the dial are easy to read and are back-lighted for night viewing. Whole-megacycle frequency selections are made with the outer ridged rings controlling transmitter and receiver separately for cross-channel operations. One-tenth megacycle selections are made with the smaller center knobs. Variable squelch is controlled by a switch mounted concentrically behind the volume control. Transmitting power over the entire range is five watts. Write in No. 71 on Reader-Service Card for more information.

PHOTO-TV STAR SCANNER

STUDIES of hundreds of photos have confirmed the success of a day-night star (or planet) scanning system developed by R. K. H. Gebel, of the WADC's Aeronautical Research Laboratory at Wright Air Development Center, Wright-Patterson AFB, Ohio. Called the "cat eye," the electronic system operates on principles similar to TV's. An optical amplifier, however, gives it a sensitivity about 1000 times better than that of an ordinary TV camera.

Coupled with a 10-in. refracting telescope, "cat eye" uses the latest WADC findings in light amplification for exposure times of 0.04 sec.

more on page 178

Write in No. 270 on Reader-Service Card >
SPACE/AERONAUTICS

Write in No. 269 on Reader Service Card at start of Product Review Section



MIDVAC SUPER ALLOYS



SOLVING MODERN DESIGN SPECIFICATIONS

Parts for Missiles—Rockets—Jet Engines are constantly calling for newer alloys to operate at higher temperatures. Alloys made by the Midvac process are currently answering these needs and new ones are being developed in anticipation of more critical operations.

Midvac Alloys insure increased tensile and impact properties, improved stress rupture strength at elevated temperature, and longer fatigue life.

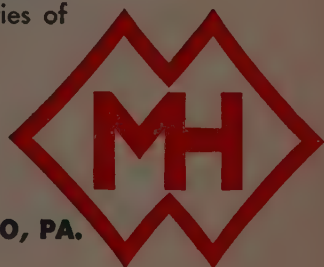
Standard commercial alloys can also be made with increased cleanliness resulting in higher properties than have been available under conventional means.

Offered in ingots, billets or forgings for the production of missile combustion chambers, tail cone assemblies, jet engine parts, aircraft landing gear components or any other parts requiring properties beyond the capabilities of conventional steels.

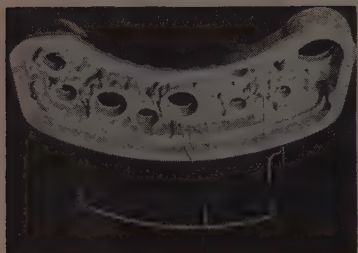
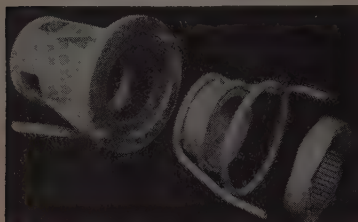
MidVac Steels

MIDVALE-HEPPENSTALL CO., NICETOWN, PHILADELPHIA 40, PA.

Subsidiary of HEPPENSTALL COMPANY, Pittsburgh, Pa.



onds or less in daylight or darkness. By electronically varying contrasts between light and dark, the system detects minute differences in light that are not sensed by conventional photo equipments. The short exposure time makes it possible to study the effect of the earth's atmosphere that gives stars their "twinkle"—a phenomenon that has long caused headaches in astrophotography.



3500-PSI AL-FIN PARTS

BONDED bi-metallic hydraulic parts now carry pressures of more than 3500 psi. They make leakproof, vibrationproof, lightweight units that operate at high efficiency, according to Al-Fin Div. Fairchild Engine & Airplane Corp., Deer Park, N. Y.

The packaged hydraulic parts are being produced by the Al-Fin molecular bonding process (*AvAge*, "New Al-Fin Developments Create New Design Opportunities," p. 26, Jan. '54). Packages are formed by bonding preformed steel tubing clusters into cast aluminum or magnesium housings. They can be mini-

aturized to degrees that used to be impossible with machined construction, it is claimed.

Wall thicknesses between passageways can be reduced to a minimum to insure sound casting. This is because the pressures are carried entirely by the steel tubing. Use of steel tubing formed to smooth contours eliminates the need for drilled and plugged construction. It also sharply reduces machining costs.

Moreover, the use of curved passageways gives higher flow efficiency. This makes possible smaller passageway diameters for a given hydraulic spec, offering further miniaturization, Al-Fin engineers point out.

The molecular bond permanently joins the steel tube to the cast aluminum. It keeps the components from loosening under varying mechanical and thermal loads. The molecular bond eliminates galvanic corrosion between dissimilar metals since, there is no air gap in which liquids could accumulate.

This construction, Al-Fin says, is being used in airborne electric generators, jet engine gear case covers, and electronic housings (see *Photos*) to provide intricate passageway systems for the circulation of liquid coolant.

More circuits can be connected to the hydraulic system simply by drilling through the aluminum body into the steel tubing and sealing the joint with O-ring seal members, according to Al-Fin. Bimetallic construction has proved itself for fluid circulation systems also by providing lightweight miniaturization, high efficiency, and low machining cost, it is claimed. Write in No. 62 on Reader-Service Card for more information.

FEEDBACK REGULATOR

THE most important feature of this lightweight missile system regulator, says Linde Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17, N. Y., is a feedback element that senses tank pressure and automatically changes the regulator delivery pressure to keep the tank pressure constant.

Thanks to the building block concept of this design, regulators can be assembled for either single or multiple-stage operation. Stages are adjustable to meet a wide variety of delivery pressures. The temperature range is -65 to $+160$ deg F. Write in No. 63 on Reader-Service Card for more information.

MARMAN

Engineering Notes



W. M. WILLIS

In looking at a finished product for the first time, one sees only the superficial aspects. At first glance it is difficult to visualize the intensive design effort, infinite refinements, and development engineering that

have led to the final product.

The Marman Conoseal is a typical example, reflecting the reduction of theory by empirical testing to ultimate simplicity in finalized design. From this point of view, it may be interesting to discuss some of the details that make this joint outstanding, meeting the extreme requirements for advanced missile systems, aircraft, and the nuclear industry.



In the sketch above, note the reverse position of the gasket and pilot length which demonstrate that an incorrect assembly is impossible. This was attained by correlating the gasket proportionate requirements of performance to the length of the pilot for assembly.

For preassembly, the angle of the gasket had to accommodate ease of installation yet accomplish closed radial forces sufficient to produce plastic flow at the gasket edges to achieve a seal of zero leakage under the most severe environmental conditions. The reposed angle of flanges also has a definite design objective which allows for ease of joint disassembly subsequent to providing a radial seal.

The sharp corners on gaskets combined with material hardness and strength as differentiated from the flanges allow unlimited usage of flanges with new gaskets.

In order that the quality of the product be compatible with the performance of critical application areas, stringent quality control standards have been established for acceptance; 10% X-ray, 100% magnaflux, special forging temperatures which limit the grain size to a standard ASTM 5 to 6. One out of each heat batch of forgings is cut and severely etched, photomicrographed, and compared to the standard grain size. Vacuum melt or similar stock is specified to establish the dispersion of carbides into a very fine pepper pattern. This allows the customer, after welding flanges to this ducting system, to use the normal cleaning and pickling methods without destroying the surface.

The results of this five-year product development have culminated in coupled joints far exceeding the performance of bolted flanged per pound of weight.

Complete test reports are available upon request.

ENGINEERING MANAGER
MARMON DIVISION, AEROQUIP CORPORATION



For Quick Connection of High Performance Tubing, Specify **MARMAN** CONOSEAL Joints

ONE BOLT FASTENS SECURELY

Connect high performance tubing quickly! Get perfect seal! Use the Marman CONOSEAL Joint that tightens with a single bolt—a simple, positive operation even in confined areas.

Important design advantages: The Marman CONOSEAL Joint requires minimum envelope clearance because its diameter is only slightly larger than the tubing it connects. Four configurations, light to heavy duty, provide maximum opportunities for weight savings.

Important operating advantages: The Marman CONOSEAL Joint seals perfectly at extreme temperatures. It joins tubing of dissimilar metals, and accommodates linear deflections up to 1/16 inch resulting from temperature and pressure variations. It has indefinite shelf life because it is all metal; and it may be used for many fluids, including liquid metals. Return the coupon for complete information.

Marman CONOSEAL Joints are available in four operating performance ranges. Standard sizes from 1" to 12" O.D. tube size. Special sizes available.

Joint Type	Temp. Range (°F.)	Max. Pressure (3" size 70°F.)
Lightweight	-300 to +1250	1200 psig
Light Duty	-300 to +750	1500 psig
Medium Duty	-300 to +1250	3300 psig
Heavy Duty	-300 to +2000	6000 psig



11214 EXPOSITION BLVD., LOS ANGELES, CALIFORNIA
IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO
Marman Products are Covered by U.S. and Foreign Patents and Other Patents Pending

Aircraft Sales Dept., Marman Division, Aeroquip Corporation
11214 Exposition Blvd., Los Angeles 64, California

Please send me full information on Marman CONOSEAL Joints. I am concerned with temperatures from _____° to _____°, pressures from _____ psi. to _____ psi. type of fluid _____ diameter _____

Name _____
Title _____
Company _____
Address _____
City _____ Zone _____ State _____

8A-2

Write in No. 271 on Reader Service Card at start of Product Review Section

EDISON

**Time Delay Relay assures
sharp, clear aerial photos...
automatically**



The F8U-1P Crusader recently set new coast to coast speed record. CAI camera control system with Edison Time Delay Relay was used to automatically provide sharp, clear aerial photographs of the entire flight.

HERE'S WHAT A CUSTOMER SAYS ABOUT EDISON TIME DELAY RELAY...

"The CAX-12 servo power unit is a very vital part of the intricate 'brain' of the automatic camera control system, and naturally, we must have absolute reliability in all components. Therefore, as you know, we have relied on Edison Thermal Time Delay Relays since the original design of this CAX-12 and similar units. Since space for this type of equipment is at a premium, the compact size was a most important factor in original selection, but our units must also withstand severe environmental testing, involving vibration, moisture, shock, pressure fluctuation and extremes of temperature. Needless to say, the Edison Relay met all of these exacting requirements in our laboratories, and we've been specifying Edison ever since!"

(The above letter was received from Chicago Aerial Industries)



Edison's Thermal Time Delay Relay being inserted in the CAX-12 servo power unit.

Chicago Aerial Industries has developed a camera control system that allows one jet pilot to do the job of ten expert aerial photographers... automatically.

Heart of this new unit is the CAX-12 servo power unit. It accurately synchronizes film speed with speed of the jet—changes lens openings in response to electronic signals—regulates shutter speed and controls driving motor on cameras.

Because this power unit is vital to the camera control system component reliability is a must. That's why CAI relies on

Edison Thermal Time Relays exclusively for CAX-12.

Edison's line of miniature time delay relays are available for a wide range of electronic applications. They are light, small, rugged and offer these advantages:

- Designed to withstand vibration frequencies to 500 CPS
- Exceptionally high rate of contact closure
- Permanent calibration and hermetic seal
- Extremely rigid mechanical structure using high-strength, high-expansion alloys.

Thomas A. Edison Industries

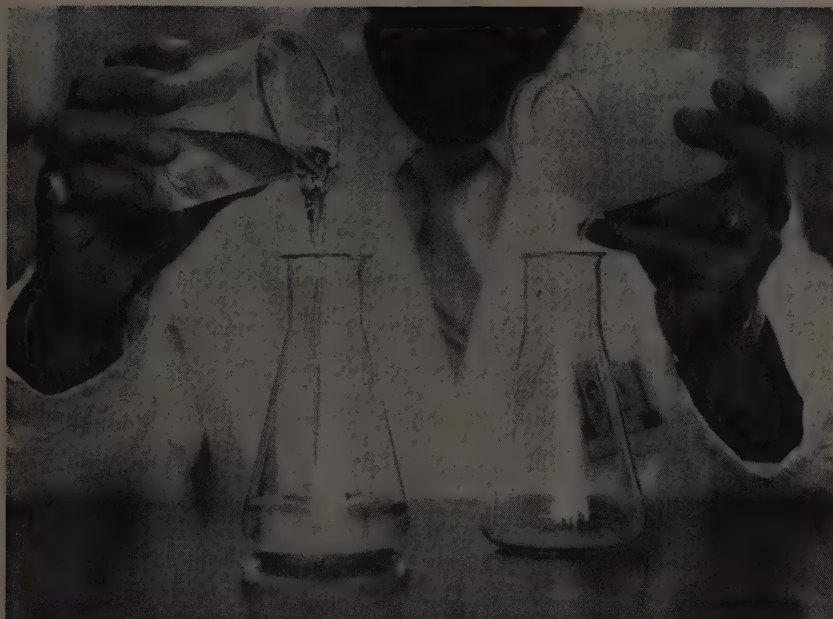
INSTRUMENT DIVISION

48 LAKESIDE AVENUE, WEST ORANGE, N. J.

EDISON FACTORY OFFICES ARE LOCATED IN: EVANSTON, ILLINOIS; DALLAS, TEXAS; DAYTON, OHIO; SHERMAN OAKS, CALIFORNIA

Write in No. 272 on Reader Service Card at start of Product Review Section





GYRO FLOTATION FLUID Retains Plasticity at -65 deg F



FEBRUARY 1959

Sperry Gyroscope Co., Great Neck, N. Y., has developed a gyro flotation fluid that retains plasticity to less than -65 deg F without artificial heating. The upper temperature limit has not yet been established, but it is above the operating requirement of 225 deg F. Formerly the gyros required continuous heat during storage and operation to keep the fluid from becoming so hard that the gyros often shat-

tered, damaging or severing the electric leads that conduct power to the gyro wheel.

Sperry chemists devised a bromine version of the chloro-fluorocarbon fluids previously used. Because the new fluid remains viscous at low temperatures, it can be brought up to operating temperature in an extremely short time without the risks common with previous flotation materials.

Write in No. 319 on Reader Service Card at start of Product Review Section

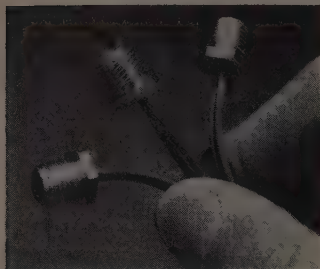
This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of aviation.

Randolph Hawthorne
Editor



product preview

IGNITION PRIMER for very high altitudes



This hermetically-sealed ignition primer has been designed for the ignition of propellants and powders at altitudes in excess of 100,000 ft. The Model 1029A cartridge minimizes static sensitivity and withstands 1000 V ac between either pin and case without ignition, says **HOLEX, Inc.**, Dept. S/A, P. O. Box 148, Hollister, Calif.

The basic load is a metallic-oxide priming mixture for the ignition of boron and similar type boosters and propellants. The device will ignite in about 13 msec when fired by means of five amps ac. Ignition times down to less than one msec are available. The device features standard screw-in construction and is normally supplied with integral #20 leads, 4½ in. long.

Write in No. 300 on Reader-Service Card

DIGITAL RECORDER has fast start and stop

The Data Tape 5-680 Series digital magnetic-tape recorder-reproducer is a versatile instrument designed for reliability and ease of maintenance, says **Consolidated Electrodynamics Corp.**, Dept. S/A, 300 N. Sierra Madre Villa, Pasadena, Calif. It is available in standard tape speeds from 30 to 150 ips, as well as special speeds, and in tape widths of ¼, ½, ¾, and one in.

Start and stop time is under three msec, and the guaranteed accuracy is within 0.05 in. in both forward and reverse directions. The nominal fast forward and reverse speed is 250 ips, and re-wind time is three min for a 10½-in. reel. An interesting feature of the equipment is the construction of the record and playback heads. A metal-to-metal technique contributes to exceptional stability of all dimensions and track alignment. The unit's design incorporates modular construction.

ANALYZER for power spectra

This new VHF Recording Spectrum Analyzer permits rapid recording of power spectra over a bandwidth continuously adjustable from zero to 50 Mc. The basic frequency coverage of 75-125 Mc can be extended to any part of the UHF or microwave range through the use of auxiliary converters. Sensitivity is -60 dbm for full-scale output; response is flat within ±1 db over entire swept band, says **Granger Assoc.**, Dept. S/A, 966 Commercial St., Palo Alto, Calif.

The new Model L-1 employs an electronically tuned local oscillator permitting front panel selection of: slow, non-recurrent sweep for permanent recording on the associated graphic recorder; 20 cps recurrent sweep for display on an auxiliary oscilloscope; or manual tuning.

Write in No. 302 on Reader-Service Card

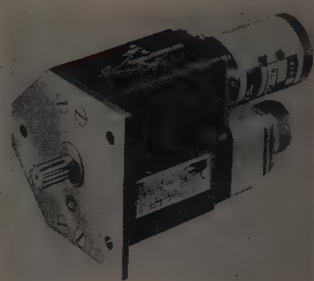
SIMULATOR for search radar



All the random and systematic phenomena basic to a completely valid simulation of radar video can be reproduced by this search radar simulator, according to **Federal Scientific Corp.**, Dept. S/A, 615 W. 131st St., New York 27, N. Y. The simulator may be used to supply inputs to tracking devices, data processors, and all other systems employing radar video.

Simulation includes effects of antenna radiation pattern, target scintillation, and receiver thermal noise. Parameters such as antenna scanning rate and beam width, transmitter pulse width and repetition frequency are under control of the operator. The signal-to-noise ratio is adjustable to within one db.

ROTARY ACTUATORS feature modular design



The modular design of these aircraft rotary actuators permits 40 different actuator packages to be made from 12 standard interchangeable components, says **Airborne Accessories Corp.**, Dept. S/A, 1414 Chestnut Ave., Hillside 5, N. J. The R-12 line, said to be the first incorporating the modular concept in rotary actuators, provides load ratings to 100 lbs/in. and speeds from .5 through 50 rpm.

The design has resulted in higher power in a smaller, lighter unit. Models weighing 1.1 lbs are available for 115-V, 400-cycle, ac operation, and .9-lb units are made for 26 V dc. The actuators are available for 115-V, 400-cycle, ac vices, intermediate positioning switches, and thermal overload protectors.

Write in No. 304 on Reader-Service Card

BEARING MATERIAL increases load range

The range of loads and speeds at which bearings can operate without any lubrication has been greatly extended through development of a new bearing material and construction, says **Dixon Corp.**, Dept. S/A, Burnside St., P.O. Drawer No. 7, Bristol, R.I.

Rulon S-Liner bearings have been run continuously for over 1000 hrs at PV values of 20,000, and intermittently at values of 40,000; oilwick lubrication permits continuous duty at values of 60,000.

Rulon S-Liner bearing construction consists of a steel-backed, woven wire-mesh supporting matrix impregnated with a new formulation of Rulon, a combination of Teflon and inorganic materials. The material can be provided as standard rolled sleeve bearings or as flat sheet that can be easily cut and formed.

Write in No. 305 on Reader-Service Card
more on page 185

TESTING AT 3500°F AND ONLY "LUKEWARM"

**CREEP AND STRESS
RUPTURE TESTING MACHINES**

**HYDRAULIC FATIGUE
TESTING MACHINES**

**HYDRAULIC UNIVERSAL
TESTING MACHINES**

**UNIVERSAL SCREW POWER
TESTING MACHINES**



As elevated temperature ranges continue to climb, needs are created for complete systems of equipment capable of testing physical properties of materials at high temperatures.

NOW — from *one* source, ready-to-operate systems incorporate all of these components:

1. BASIC TESTING MACHINE
2. STRAIN MEASURING INSTRUMENTATION for atmosphere, controlled atmosphere and vacuum furnaces
3. COMPLETE HIGH TEMPERATURE ACCESSORIES including furnaces, temperature controllers, vacuum pumps and complete related instrumentation.

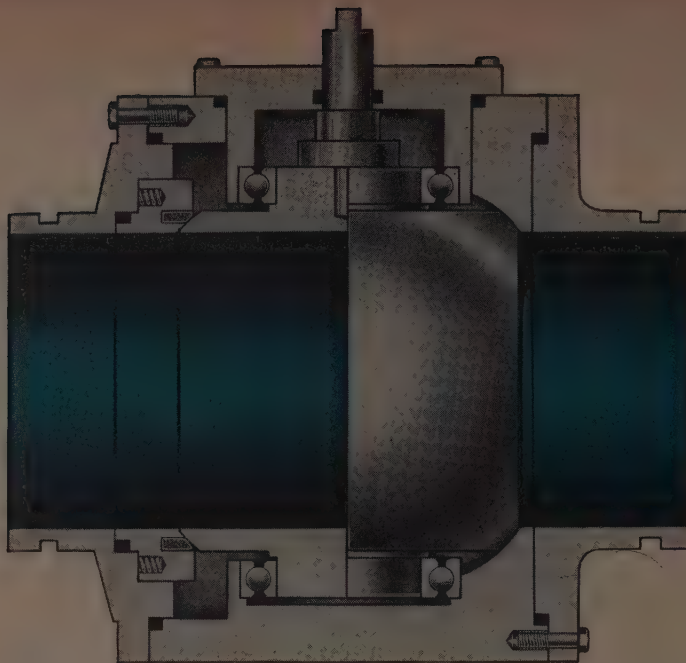
With testing temperatures up to 3500°F currently available, Riehle engineers expect to announce a new range up to 4000°F in the near future.

For saving time on vital projects, rely on RIEHLE. Contact us regarding your requirements for physical testing at elevated temperatures.

Riehle® TESTING MACHINES
A DIVISION OF
American Machine and Metals, Inc.

DEPT. SA-259, EAST MOLINE, ILLINOIS

Write in No. 46 on Reader Service Card at start of Product Review Section



HYDROMATICS *FLO-BALL*® VALVES

The accepted standard of maximum performance and reliability

100% FLOW EFFICIENCY

Hydromatics' exclusive FLO-BALL design provides a straight-thru unrestricted fluid path, exactly equal to the pipe line diameter.

PERFECT SEALING

Zero leakage is assured through the use of a precision ball—the ideal geometric form for perfect sealing contact.

LOW OPERATING TORQUE

Ball rotates in precision bearings which absorb all pressure loads. Pressure balanced valve seat further minimizes forces on ball, reducing frictional drag.

LONG LIFE

Seat is always in sealing contact with the ball surface, resulting in a self-wiping, self-lapping action that insures long, trouble-free life.

HIGH SPEED ACTION

Only 90-degree rotation is required to fully open or close valve. Full travel as fast as 5 milliseconds.

RELIABILITY

Simple construction, with only one rotating part, provides built-in reliability and rugged, dependable operation.

CRYOGENIC AND CORROSIVE APPLICATIONS

Hydromatics' FLO-BALL valves, with new diaphragm sealing and unrestricted fluid path, have been proved the best valves for operation with LOX, Liquid Nitrogen, Helium, Hydrogen Peroxide, Red Fuming Nitric Acid and Hydrazine.

MODULAR ARRANGEMENT

Only FLO-BALL design, with its rotating valve action, permits side-by-side grouping of several valves, all driven simultaneously by a single actuator.

VERSATILITY

Only FLO-BALL design makes possible the interchanging of manual, motor or pressure actuators without changing the valve body.

HYDROMATICS, the world's leading designer and manufacturer of high performance ball valves for military and industrial applications, offers the most extensive selection of designs to meet all your requirements; Manual, motor or pressure operated. For cryogenic, corrosive or general service media. Pressures from vacuum to 10,000 psi. Sizes from 1/4 inch to 12 inches.

Hydromatics, Inc.

70 Okner Parkway, Livingston, New Jersey

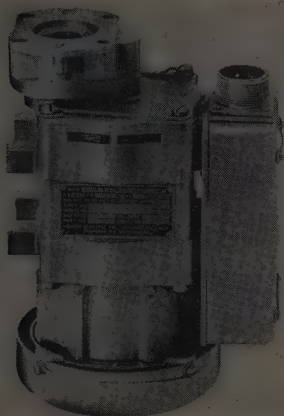
Hydromatics, Inc.

HYDROMATICS FIELD ENGINEERING OFFICES:

Pasadena, 35 N. Arroyo Pkwy., RYan 1-7448 / Denver, 829 15th St., AMherst 6-2714 / Washington, 1413 K St. N. W., STerling 3-3612

Write in No. 47 on Reader Service Card at start of Product Review Section

MOTOR designed for rugged duty



The Model D-1000 28-V dc motor, originally designed to drive a 3000-psi, 0.5-gpm hydraulic aircraft pump, delivers 1.6 hp at 2000 rpm when operating at 69 amps, says Hoover Electric Co., Dept. S/A, Hangar 2, Port Columbus Airport, Columbus 19, O. Applications include pneumatic compressor, fuel pump, antenna rotating and cargo rescue winch drives, and units are available for both missiles and aircraft.

The motor features explosion-proof construction, radio noise suppression, and the ability to withstand continuous starting, at rated load, at two second intervals and under severe in-rush conditions. Higher output speed to 25,000 rpm may be obtained by deleting the reduction gear box.

Write in No. 110 on Reader-Service Card

CABLE SYSTEM isolates vibration

A network of stainless steel cable is being manufactured as a vibration isolating system for aircraft and missile components, such as gyroscopes and gyrocompasses. Finnflex cable systems have been laboratory tested to sustain high g loadings superimposed on high vibratory loadings comparable to those of acceleration loads during missile firing or violent aircraft maneuvers, says T. R. Finn & Co., Inc., Dept. S/A, 200 Central Ave., Hawthorne, N.J.

Vibration damping results when the cable's individual strands rub together during cable motion. Efficiency at any attitude, excellent shock attenuation characteristics, and minimum space requirements are among the advantages of the system. It can be used for either high or low frequency vibration by changes in cable length, diameter, materials, and other factors.

Write in No. 111 on Reader-Service Card

COMPASS CALIBRATOR eliminates manual system

A unique compass calibrating system that assures a quick, precise check of the magnetic compass of parked aircraft and missiles has been developed under WADC sponsorship by Sperry Gyroscope Co., Dept. S/A, Great Neck, N.Y. The system is expected to save millions of dollars in ground maintenance and flight costs, as well as contribute to greater instrument accuracy.

Three components are involved: an electrical console, which artificially changes magnetic heading; a surveyor's tripod; and a transit modified to include a magnetic sensing device. The aircraft compass' flux valve is first placed in a small turntable mounted on the tripod to align it with magnetic north and to determine what electrical currents will cancel out the natural local magnetic field. Next, the valve is reinstalled and optically aligned. The electrical console, cable-connected to the compass system, is then switched to each of 24 magnetic headings and a meter provides precise indications of the errors requiring compensation to permit accurate compass readings. The modified transit is used as a field monitor to determine direction of the magnetic field about the aircraft and to measure changes in the field during actual compass calibration. The aircraft need not be moved during the entire procedure.

Write in No. 112 on Reader-Service Card

TUBE SOCKETS are compression-mounted



This chemelec teflon subminiature tube socket has high reliability under extreme shock, vibration, high temperature; low-loss insulating qualities and zero moisture absorption, according to Fluorocarbon Products, Inc., Dept. S/A, Camden, N.J.

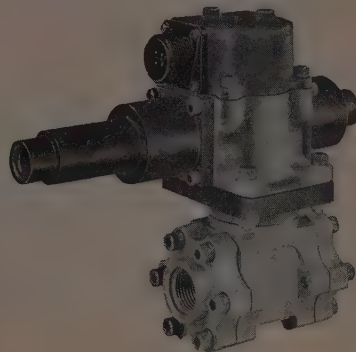
Its compression-mounted design requires no mounting hardware. This socket is simply pressed into a single chassis hole, slightly smaller than the teflon body of the socket.

Write in No. 113 on Reader-Service Card
more on next page



1/2" MOTORIZED FLO-BALL VALVE 100% flow efficiency — for general service media up to 3000 psi

Extremely light weight and compact, suitable for a wide range of aircraft and missile applications, both airborne and ground support. Provides perfect sealing and 100% flow efficiency for general service media (jet fuels, hydraulic fluids, water, alcohol, helium, hydrogen, oxygen, etc.) at pressures up to 3000 psi and temperatures from -65° to 200°F . The DC motor actuator includes automatic current shut-off and a positive Geneva-Lock mechanism. Valve is of bi-stable design — in the event of electrical power failure, the valve will remain in its last position, either open or closed. Included is a built-in microswitch for remote observation of valve position. Flanges, which are removable and interchangeable, may be specified per AND-10050, AND10056, NPT or ASA.



1/2" CRYOGENIC FLO-BALL VALVE 100% flow efficiency, zero leakage at 1000 psi, -350°F

Pressure actuated ball valve of extremely compact design, weighing only 1.9 lbs. For airborne and ground support applications with cryogenic media, such as LOX bleed, dump or vent control. Valve is operated by a sealed double-acting actuator with spring biased closing. Actuator is thermally isolated from the valve body to guarantee fast positive action at cryogenic temperatures. Operating times available from 25 milliseconds to 2 seconds.

Valve includes a sealed, rotary action snap switch for remote observation of valve position. The switch may be externally adjusted. Flanges, which are removable and interchangeable, may be specified per AND10050, AND10056, NPT or ASA.

Hydromatics, Inc.

70 Okner Parkway, Livingston, New Jersey
Write in No. 48 on Reader-Service Card

MICROTOMIC

FIRED AT 2000° F



Trademarks
Reg. U.S.
Pat. Off.

Intense heat is important in the making of pencil lead. Under the supervision of Eberhard Faber pencil engineers, Microtomic leads are fired up to 2,000 degrees Fahrenheit in scientifically-controlled ovens. One more reason why Microtomic holds a finer point longer... produces rich, black lines... and is the natural choice of professionals. Bull's eye identifies each of 18 uniform degrees.



110th Anniversary, 1849-1959

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WILKES-BARRE, PA. • NEW YORK • TORONTO, CANADA

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186

PRODUCT REVIEW

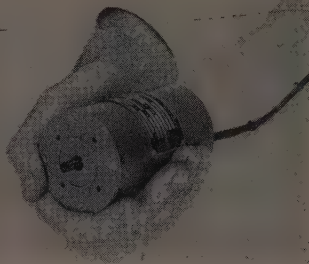
EXHAUST NOZZLES withstand rocket heat

These graphite exhaust nozzles for solid-propellant rockets can withstand tremendous thermal shock and high temperatures without melting, fusing, or distortion, says Stackpole Carbon Co., Dept. S/A, St. Marys, Pa. In addition, erosion and wear during the firing time of a rocket are held to extremely close limits.

The graphite inserts can be readily machined to the close tolerances required for the tapered throat. A variety of nozzle types is available.

Write in No. 114 on Reader-Service Card

MISSILE MOTOR is lightweight



This one-hp, 22,000-rpm missile motor is four in. long, 2½ in. in dia, and weighs 2 3/4 lbs. It is ideal for a wide range of pump and gear box applications, says Hoover Electric Co., Dept. S/A, Hangar 2, Port Columbus Airport, Columbus 19, O.

The 400-cycle, 208-V, three-phase ac model C-2610 has a ¼-in. dia by ½-in.-long shaft, which is slotted by a Woodruff Key. The shaft can be a pinion gear, flat, splined, or any desired shape. The intermittent-duty motor is capable of producing 1.75 hp.

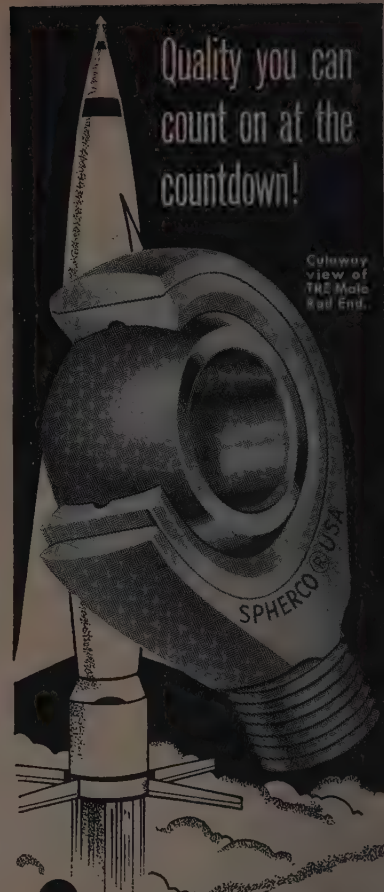
Write in No. 115 on Reader-Service Card

PRESSURE SWITCHES for missiles

This series PS3800 miniaturized, lightweight, high-pressure, vibration-damped pressure switches is designed for missile applications. Each weighs about 0.4 lb and operates in inert gases and fuels, engine and hydraulic oils and aromatic fuels and is designed to withstand vibrations up to 25 g's, from ten to 2000 cps, according to Southwestern Industries, Inc., Dept. S/A, 5580 Centinela Ave., Los Angeles 45, Calif.

The pressure switches are externally adjustable and can be re-adjusted through their actuation pressure range as required. They are available in actuation pressure ranges from 400 to 2000 psig (proof pressure 4000 psig) or 2000 to 3500 psig (proof pressure 5000 psig).

Write in No. 116 on Reader-Service Card
more on page 190



Quality you can
count on at the
countdown!

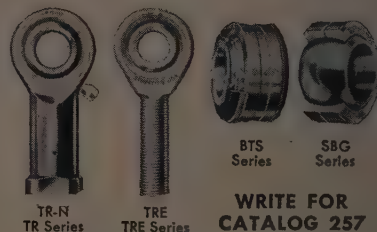
Cutaway
view of
TRE Male
Rod End.

SPHERCO®

SPHERICAL

BEARINGS & ROD ENDS

Here's quality you can count on for transmission of motion. SPHERCO solid one-piece race protects the ball from binding and pinching under load and resists shock, vibration and impact. An exclusive SPHERCO method of locking the insert in a rod end body, assures you of a smooth, free running but rugged rod end bearing.



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SPHERCO®

A PRODUCT OF

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STEPHENS-ADAMSON MFG. CO.

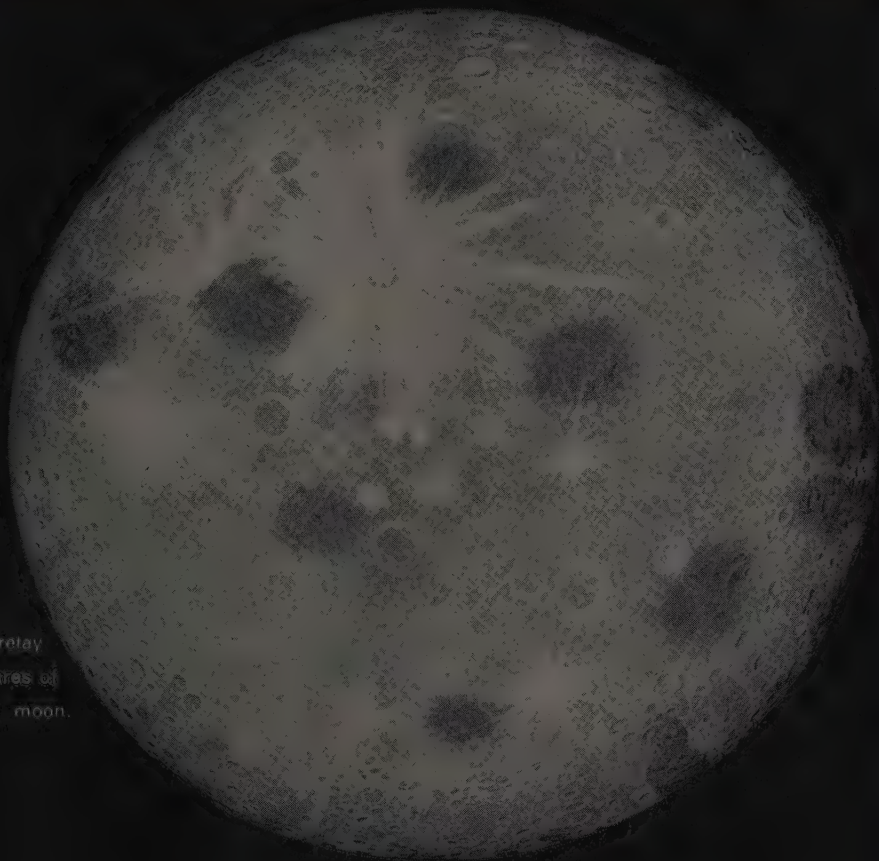
2 RIDGEWAY AVE. • AURORA, ILL.

Write in No. 80 on Reader-Service Card
SPACE/AERONAUTICS

* *This scientific representation based on current knowledge was prepared under the supervision of Dr. I. M. Levitt, Director of the Franklin Institute Planetarium.*

THE OTHER SIDE ? *

Soon space probes will relay
back to the earth pictures of
the other side of the moon.



WILL IT LOOK LIKE THIS ?

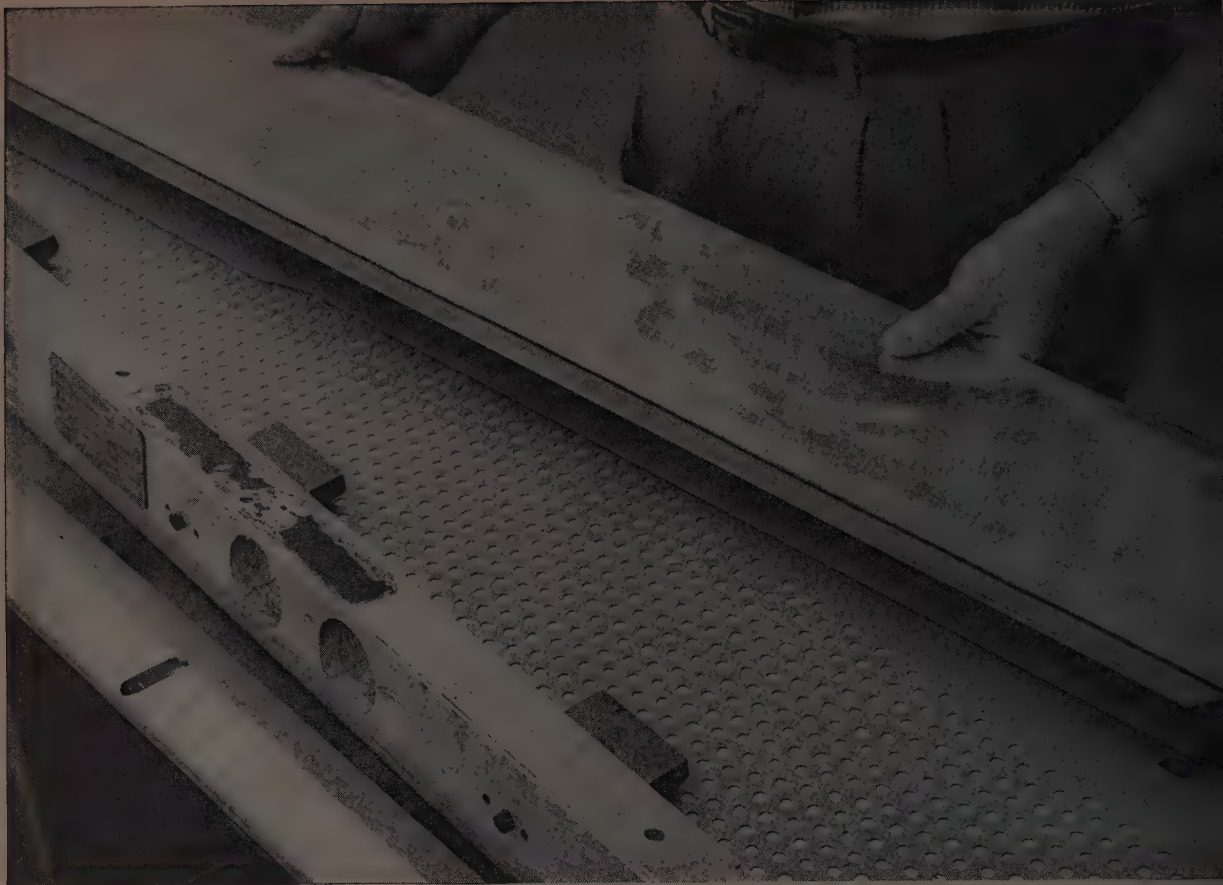
At this time no one knows. But intricate electronic devices in projected lunar vehicles will reveal this hidden surface. Instrumentation has extended the long arm of man to reach as far as the mind can project. With such devices as a key, science can unlock the door to the future and to the very universe itself.

At the Decker Corporation our sole occupation is instruments—instruments which range from a device to measure a millionth of an inch on earth to one recording the density of the most tenuous of the space atmospheres subject to man's reach.

On the mysterious road to space will be found Decker instruments to provide beacons to light up the future.

THE **DECKER CORPORATION** Bala Cynwyd, Pa.

Write in No. 81 on Reader Service Card at start of Product Review Section



Pressure pad of FAIRPRENE® smooths an aileron's skin at 350°F.

Shown above, an aileron section is placed in the fixture where heat and pressure cure an adhesive that bonds the skin to a honeycomb core. Section is a trailing edge for Northrop Aircraft's T-38, 2-seater supersonic jet trainer. Perforated material is "Fairprene"®* silicone rubber sheet stock. After placing the part, another layer of "Fairprene" is put on top, pressure is applied, and the part is heated to about 350° F.

Northrop found only "Fairprene" is economical for service at such temperatures. Because of its resilient properties,

"Fairprene" prevents an indentation or scratch from a speck of dirt—helps assure the absolutely smooth fuselage skin that's a must for jet-age speeds.

This is an example of the superior performance of "Fairprene" that could prove useful for your product or process. If you need a material resistant to gas, oils, solvents or corrosive chemicals, abrasion or flex cracking—materials that retain their properties at -100°F. or 500°F. ... or possess superior insulation or anti-stick properties, there's a Du Pont coated fabric or sheet stock to do the job.

And to help you use these materials most effectively, you can call on free technical help from Du Pont. For more specific information on the variety of "Fairprene" materials available, mail the coupon.



REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
... THROUGH CHEMISTRY

DU PONT INDUSTRIAL COATED FABRICS

COATING MEDIUMS

Neoprene • Buna-N • Silicone • Polyacrylate
Chlorosulfonated Polyethylene • TFE-fluorocarbon • Butyl
Acrylic • Polyamide • Polyethylene • Polysulfide

SUBSTRATES

Fabrics

Cotton • Nylon • "Dacron"† • Asbestos
Glass • Rayon • TFE-fluorocarbon

Also elastomer sheet stocks without fabric inserts and cements

*"Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements.

E. I. du Pont de Nemours & Co. (Inc.), Dept. SA-92
Fabrics Division, Wilmington 98, Delaware

Please send me further information about coated fabrics.

I am interested in using a coated fabric for _____

Name _____ Title _____

Firm _____

Address _____

City _____ State _____

†"Dacron" is Du Pont's registered trademark for its polyester fiber

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Write in No. 83 on Reader-Service Card
SPACE/AERONAUTICS



COUNTER- COUNTER MEASURES

Jamming techniques pierce the shield of countermeasures

In the silent world of electronic defense, there are two ways to move and observe—unobserved. One involves the airborne jamming equipment LMED is currently producing for the B-52. The other is the new Anti-Jamming techniques LMED is currently developing for the Air Force to give future weapons systems a high degree of countermeasures immunity. Tomorrow's airborne weapons systems will need secure detection and reliable countermeasures. LMED is intimately experienced in both. For brochure: "Moves and Countermoves in an Unending Struggle for the Electronic Spectrum," write Dept. 5E.

LMED
LIGHT MILITARY ELECTRONICS DEPARTMENT

Progress Is Our Most Important Product

GENERAL  ELECTRIC

LIGHT MILITARY ELECTRONICS DEPARTMENT
FRENCH ROAD, UTICA, NEW YORK

A DEPARTMENT IN THE DEFENSE ELECTRONICS DIVISION

COMPONENT TESTER uses card programming



Incoming inspection of transformers, relays, resistors, transistors, diodes, capacitors, and similar items is performed automatically by this component tester. The unique feature of this instrument is its ability to make a complete series of tests according to values indicated by a punched card, thus enabling it to make complex tests on a component, says California Technical Industries, Dept. S/A, 1416 Old County Rd., Belmont, Calif.

The simple method of programming requires only a business-machine type of card and an ordinary hand punch. A single hole punched in the transformer section, for example, schedules tests for primary impedance, winding ratio, and winding polarity.

Write in No. 117 on Reader-Service Card

TRANSCEIVER is simple to operate

Simplified controls, voice actuation of the transmitter function, and automatic load control are features of the 32RS-1 HF single sideband communication transceiver, says Collins Radio Co., Dept. S/A, Cedar Rapids, Ia. The transceiver has an output of 100 W PEP on any one of four pretuned channels in the 1.6 to 12-mc frequency range.

The highly stable unit is available for rack mounting or may be obtained in a cabinet version.

Write in No. 118 on Reader-Service Card

THERMOCOUPLES for 80,000 psi

This leak-proof high-pressure thermocouple is for use in pressure systems to 80,000 psi and temperatures to 1000 deg F. Used to measure temperature differentials it is designed for installation in reaction vessels and various types of fittings where $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ in. diameter openings are provided, says American Instrument Co., Dept. S/A, 8030 Georgia Ave., Silver Spring, Maryland.

Each thermocouple is built into a high-pressure compression fitting and can be installed merely by tightening a gland nut in the same manner as when making a super-pressure connection.

Write in No. 119 on Reader-Service Card

CAM ASSEMBLY made in one piece



A cam, shaft and gear fashioned in one piece from bar stock is one in a line of precision cams made for aircraft and missile applications by Eonic, Inc., Dept. S/A, 456 E. Hollywood, Detroit 3, Mich. Cams are produced by the company for turbine blades, aircraft landing gear, fuel and temperature control, and other uses.

The one-piece cam was made for Servo-mechanisms, Inc., for installation in a barometric altitude controller. The metal used was 440-F stainless. The gear has 225 teeth in a 2 11/32-in. dia, and a tooth-to-tooth tolerance of .0002 in.; total composite error is held to .0007 in. The cam tolerance is $\pm .0001$ in. Among other types, the line includes face and cylindrical cams, two and three dimensional cams for ballistic, computer and instrument use, master cams for duplicating machines, and gas turbine cams.

Write in No. 120 on Reader-Service Card

NOW!

"FINGER FLEXIBILITY"

IN TEFLON*

HOSE IN ALL

DIAMETERS

TEFLON IS A TRADEMARK

TEFLEX INC. TRADEMARK

REFLEX KLYSTRONS cover X- & K-bands



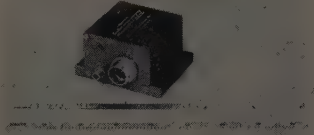
The four lightweight, ruggedized reflex klystron tubes in the IK20 series cover the 8500 to 11,700-mc range at power outputs to 50 mw. The ceramic-metal tubes are specifically designed for airborne and missile radar systems, says Eitel-McCullough, Inc., Dept. S/A, San Bruno, Calif.

These units withstand 15-g vibration in any reference plane, with less than 100-kc frequency deviation. Noise-free tuning over the entire range is achieved by means of a non-contracting, non-microphonic tuner. The tube's low beam voltage requirements and simple radiation cooling contribute to weight reduction and minimum complexity of associated equipment. Seal temperature is +250 deg C.

Write in No. 121 on Reader-Service Card

AMPLIFIERS are transistorized

These airborne transistorized, amplifiers, one-third the size of equivalent tube-type units and requiring one-fifth their plate power, are designed for missile and aircraft use, says Gulton Industries, Inc., Dept. S/A, 212 Durham Ave., Metuchen, N.J. They may be used to amplify

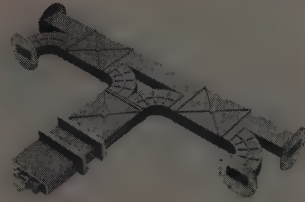


signals from high impedance transducers for direct input to standard electronic meters, recorders, or telemetry equipment.

Models F-510TU and F-528LU are said to feature special circuit techniques, very high impedance, and continuously variable gain. They are anti-microphonic, and maintain a linearity within two per cent up to the maximum overload. The units, both of which weigh under five oz, operate with a recommended minimum load of 10 K.

Write in No. 122 on Reader-Service Card

DIPLEXER for S-band



The BL-584 is an S-band diplexer used primarily for connecting two transmitters operating at different frequencies to a common antenna feed, according to Bomac Laboratories, Inc., Dept. S/A, Salem Rd., Beverly, Mass. The two echo signals at the two frequencies are separated into receiver channels.

Continuous variation of the two duplexing frequencies is obtained from a pair of ganged plungers, and a replaceable section makes it possible to duplex many frequency combinations. The low crosstalk device may also serve as a continuously variable directional coupler. Attenuation at either output can be varied from about 0.2 to about 35 db.

Write in No. 123 on Reader-Service Card

more on page 193

INSIDE AND OUT... MADE RIGHT IN OUR OWN PLANT

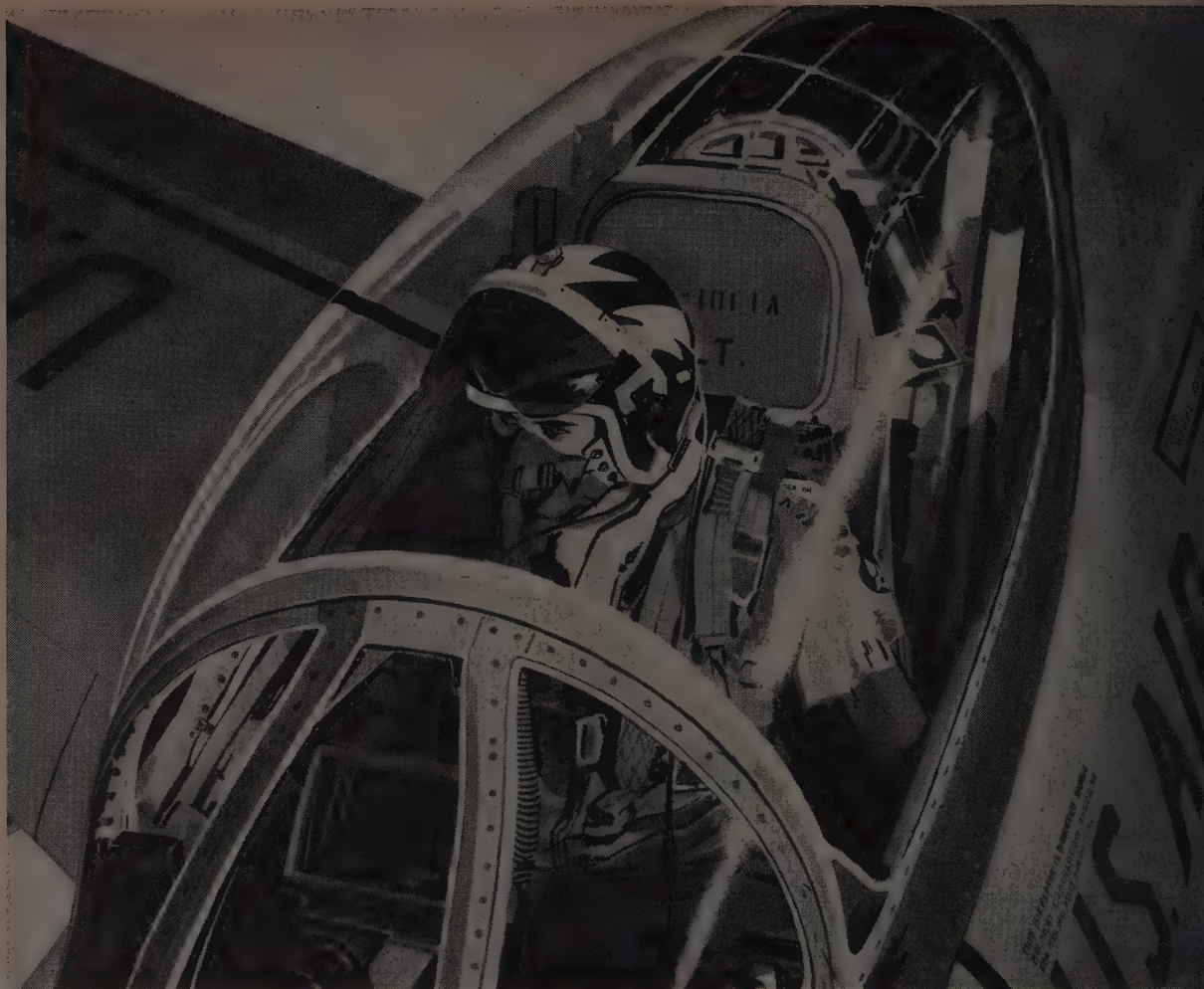
Titeflex®

TITEFLEX, INC.
Hendee Street,
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Springfield "400"

There is nothing like Teflon flexible hose for tough applications. Now, for the first time, you get "finger flexibility" in large diameters up to four inches with Springfield "400" . . . an exclusive new development by Titeflex. Short bend radius, long lengths, plus "Zero Motion Braid" make Titeflex Springfield "400" the big news in Teflon hose. Write for complete information, Bulletin 400.

Write in No. 84 on Reader Service Card at start of Product Review Section



This "bubble" owes its complexion to Polyken® tape

NOT A SCRATCH... NOT A DENT... THANKS TO THE MODERN METHOD OF SURFACE PROTECTION

The cockpit canopy of a fighter plane can be easily scratched during manufacture. So makers of supersonic aircraft take no chances. They protect its relatively "soft" surface with pressure-sensitive tape.

Not just *any* tape, though. Canopies are too valuable for that. Throughout handling and storage, they're covered with special Polyken tape.

Whatever surfaces you want to protect (from soft plastic to tough steel), there's a Polyken tape that unwinds easier, conforms better, gives superior surface protection, and pulls off clean.

THE MODERN TOOL... AT WORK FOR MODERN INDUSTRY



For advice on your surface-protection problem —check with the Polyken Industrial Tape Distributor nearest you, or write to the Polyken Sales Division, 309 W. Jackson Blvd., Chicago 6, Illinois. Dept. SA-2.

Polyken

INDUSTRIAL TAPES

THE KENDALL COMPANY
Polyken Sales Division

DC MOTOR
has unusual brush holder



This 28-V dc motor for aircraft, missile and other uses delivers 2.0 hp at 3000 rpm, according to Hoover Electric Co., Dept. S/A, Hangar 2, Port Columbus Airport, Columbus 19, O. The D-820 motor has an integral fan for efficient cooling and it may be equipped for explosion-proof operation.

The motor contains a brush holder designed to permit even pressure over the full wear range of the brush, which results in even power output and assures high-altitude operation with a minimum of brush arcing. The motor, originally designed to drive a 3000-psi, one-gpm hydraulic pump for aircraft, is available in modified versions of from one to 15 hp.

Write in No. 124 on Reader-Service Card

TUNABLE FILTER
weighs 13 lb.

Model UF-2 double-cavity tunable filter provides high off-channel rejection when used with receivers and transmitters in the 216-220 Mc telemetering and 225-400 Mc communications bands. The high-Q response permits interference-free operation on closely-spaced channels of two equipments on a common antenna or on antennas in close proximity, says Granger Assoc., Dept. S/A, 966 Commercial St., Palo Alto, Calif.

Designed for aircraft or ground use, the UF-2 features light weight (13 lb), minimum size ($\frac{1}{2}$ ATR), rugged construction and temperature compensation. Operating frequency is adjustable over the full range by means of a front panel 99-turn crank dial with a positive lock. An output indicator facilitates precise adjustment.

Write in No. 125 on Reader-Service Card
more on next page

*Trainer to X-15...
and beyond*

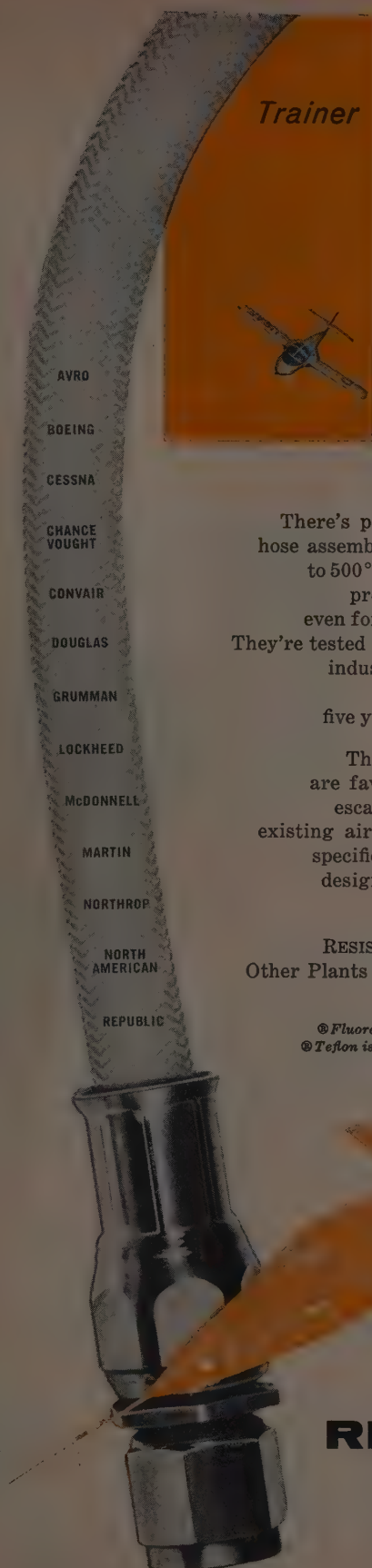
**ALL fly with
Fluoroflex®-T
hose of Teflon®**

There's performance to spare in Fluoroflex-T hose assemblies. High temperatures? They serve to 500°F... and beyond, in some cases. High pressures? They've passed rigid tests even for 4000 psi systems. Long impulse life? They're tested to 250,000 cycles... more than *double* industry standards. Optimum reliability? They've been flying for more than five years in jet and reciprocating aircraft.

That's why Fluoroflex-T hose assemblies are favored for fuel, lubrication, hydraulic, escape and fire control systems in so many existing aircraft. And that's why they're being specified for so many aircraft now being designed — they have performance to spare.

For data, write Department 195/
RESISTOFLEX CORPORATION, Roseland, N. J.
Other Plants: Burbank, California; Dallas, Texas.

© Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
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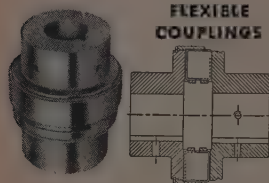


RESISTOFLEX

Write in No. 86 on Reader Service Card at start of Product Review Section

Lovejoy

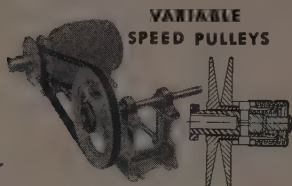
POWER TRANSMISSION EQUIPMENT EASILY INSTALLED, MAINTENANCE-FREE



**FLEXIBLE
COUPLINGS**

**REQUEST
CATALOG
C-58**

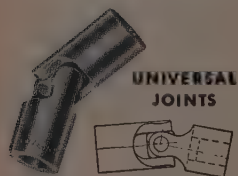
Bores (max.)..... $\frac{3}{16}$ " to $9\frac{1}{2}$ "
O.D. $\frac{3}{16}$ " to $21\frac{1}{2}$ "
Wt. $\frac{1}{2}$ oz. to 1500 lb.
H.P.1/20 to 4250
Torque (static). $1\frac{1}{2}$ to 5100 ft.-lbs.



**VARIABLE
SPEED PULLEYS**

**REQUEST
CATALOG
P-58**

Bores (max.)..... $\frac{1}{2}$ " to $1\frac{1}{2}$ "
O.D.3" to $13\frac{3}{4}$ "
Belt Sizes.....A to $2\frac{3}{4}$ TW
Speed Ratios.....1-1 to 8-1
H.P. (1750 rpm.)..... $\frac{1}{4}$ to 15



**UNIVERSAL
JOINTS**

**REQUEST
BULLETIN
020**

Bores..... $\frac{1}{4}$ " to $2\frac{1}{2}$ "
Hub Dia. $\frac{1}{2}$ " to $4\frac{1}{2}$ "
Static Torque
340 to 130700 in.-lbs.
H.P. (100 rpm.)..... $\frac{1}{2}$ to 207

**SHAFT
MOUNTED
GEAR
REDUCERS**

**REQUEST
CATALOG
R-58**

18 Models From Stock
Speeds.....8 to 425 R.P.M.
H.P.Fractional to 120
Ratios.....Single 4.5:1 Nominal
Double 14.7:1 Nominal
Hollow Shafts..... $1\frac{1}{16}$ to $5\frac{1}{8}$ in.

LOVEJOY FLEXIBLE COUPLING CO.

4842 WEST LAKE STREET • CHICAGO 44, ILLINOIS
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194

DATA REVIEW

RELAY is micro-miniature

The Powrmite is a new two-pole double-throw, two amp hermetically sealed micro-miniature relay of rugged construction and designed to withstand shock of 50 g's, 11 ms; vibration of ten-55 cps @ 0.06 amplitude and 55-2000 cps @ 20 g; with an ambient temperature range of -65 to +125 deg C, says Filitors, Inc., Dept. S/A, Port Washington, N.Y.

The Powrmite is available in four mounting styles.

Write in No. 126 on Reader-Service Card

FUEL CONTROL for jet engine



An automatic, hydromechanical fuel control that compensates for changes in pressure, temperature and airspeed has been designed for jet engines in the 30,000-lb thrust class. The JFC-36, which will be used in the J-58 engine, also regulates the afterburner nozzle diameter and compressor bleeds, according to Hamilton Standard Div., United Aircraft Corp., Dept. S/A, Windsor Locks, Conn.

The integrally cast cores of the control contribute to low weight, as well as simplified manufacturing procedures and consequent increased design flexibility. The control is made of special high-temperature aluminum alloys and features metallic seals.

Write in No. 127 on Reader-Service Card

SOLENOID has very fast response

The Model R. S. 5178 miniature solenoid has an ultra-high-speed response, according to Telecomputing Corp., Dept. S/A, 915 N. Citrus Ave., Los Angeles 38, Calif. Start of the .015-in. stroke occurs at six msec, max, and stroke completion occurs under 13 msec from closing circuit.

The unit, which will operate with a ten-lb load, requires 20 V dc at 78 deg F, and it operates over an ambient -65 to +250 deg F range. It is 1.410 in. high and has a case dia of 1.063 in.

Write in No. 128 on Reader-Service Card
more on page 198

FLIGHT DATA and CONTROL ENGINEERS

Cross new frontiers in system electronics at The Garrett Corporation.

High-level assignments in the design and development of system electronics are available for engineers in the following specialties:

1. ELECTRONIC AND FLIGHT DATA SYSTEMS AND CONTROLS A wide choice of opportunities exists for creative R & D engineers having specialized experience with control devices such as: transducers, flight data computers, Mach sensors, servo-mechanisms, circuit and analog computer designs utilizing transistors, magamps and vacuum tubes.

2. SERVO-MECHANISMS AND ELECTRO-MAGNETICS Requires engineers with experience or academic training in the advanced design, development and application of magamp inductors and transformers.

3. FLIGHT INSTRUMENTS AND TRANSDUCERS

1) DESIGN ANALYSIS Requires engineers capable of performance analysis throughout preliminary design with ability to prepare and coordinate related proposals.

2) DEVELOPMENT Requires engineers skilled with the analysis and synthesis of dynamic systems including design of miniature mechanisms in which low friction freedom from vibration effects and compensation of thermo expansion are important.

4. PROPOSAL AND QUALTEST ENGINEER For specification review, proposal and qualtest analysis and report writing assignments. Three years electronic, electrical or mechanical experience required.

Forward resume to:
Mr. G. D. Bradley

THE GARRETT CORPORATION

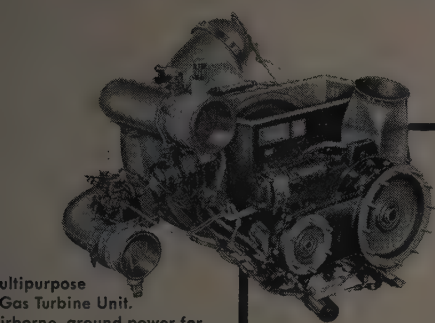
9851 S. Sepulveda Blvd.
Los Angeles 45, Calif.

DIVISIONS:

AIRsearch Manufacturing—Los Angeles
AIRsearch Manufacturing—Phoenix
AIRsearch Industrial
Air Cruisers • Airsupply
Aero Engineering
AIRsearch Aviation Services

Check Employment Inquiry Form Page 155
SPACE/AERONAUTICS

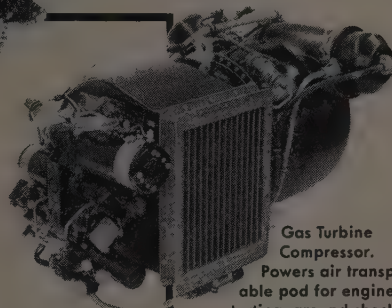
AiResearch gas turbines proved most versatile and reliable...



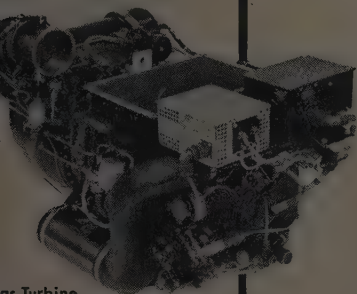
Multipurpose Gas Turbine Unit. Airborne, ground power for heating, cooling, starting, electrical, hydraulics, pressurization of military aircraft.



Gas Turbine Power Unit. Aircraft and missile ground support to drive generators, pumps, compressors. Weighs only 45 lbs.

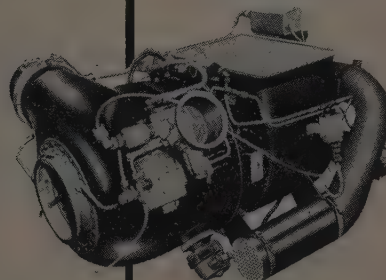


Gas Turbine Compressor. Powers air transportable pod for engine starting, ground check-out, ice and snow removal.

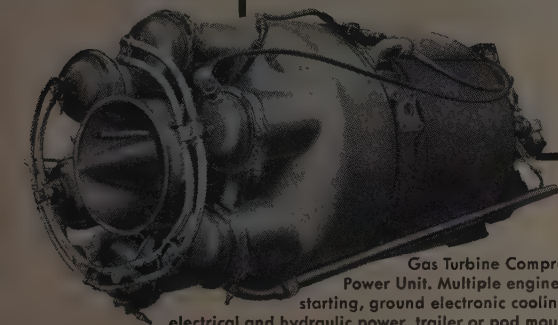


Gas Turbine Compressor. Standby flight pneumatic power for turbine-powered transports.

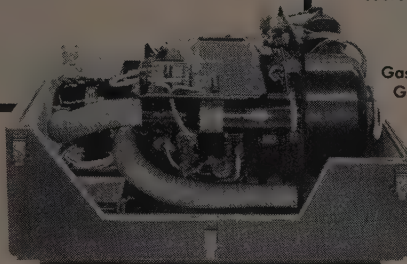
**8,000
now in
operation**



Gas Turbine Compressor Power Unit. Electrical and pneumatic ground power source for jet transports.



Gas Turbine Compressor Power Unit. Multiple engine starting, ground electronic cooling, electrical and hydraulic power, trailer or pod mounted.



Gas Turbine Generator Set. Primary electrical power for missile launchers, guidance and refrigeration systems.

AiResearch Gas Turbines are used in hundreds of applications: auxiliary power and ground support for missile systems, military and commercial aircraft; main engine starting, electrical and pneumatic power, air conditioning, pressurization, pre-flight check-out, snow and ice removal; prime

power for helicopters; variety of ground applications or aboard aircraft for mobile or stationary use.

Advantages: these lightweight units are air transportable as fixed installations, detachable pods or portable vehicles; supply low pressure air and shaft power from 30 H.P. to 850 H.P.;

provide variety of electrical power — 9 to 150 KW, 60, 400 and 1200 CPS, AC or DC; have highly refined self-regulating controls and operate in any weather; have instant push-button starting; time between overhauls 1000 hours or 3000 starts.

Your inquiries are invited.



ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

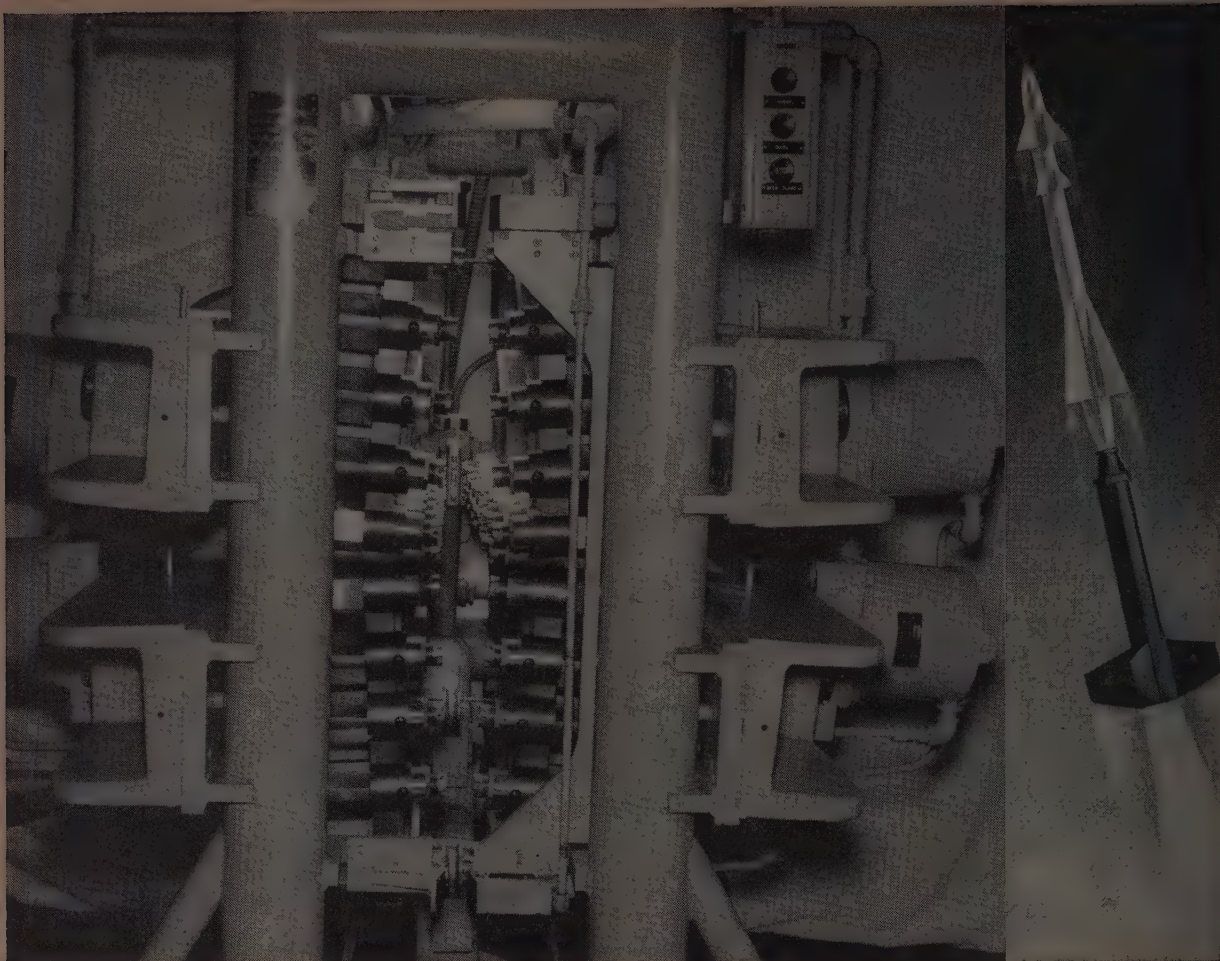
THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

Write in No. 88 on Reader Service Card at start of Product Review Section



Gardner-Denver air drills in special fixture drill holes for Nike fins.

Single air tool setup drills and countersinks 108 holes in 2 minutes

A PATTERN OF MULTIPLYING PRODUCTIVITY



A 100-year philosophy of growth—*there's no substitute for men*—has been confirmed again and again by Gardner-Denver air tool specialists. Their assistance in planning multiple screw driving, nut setting, and drilling setups has helped men in industry everywhere multiply productivity and cut costs.



One phase of fin fabrication for Nike missiles calls for drilling and countersinking 108 holes to exacting depths. Gardner-Denver air drills in this special fixture do the job in two minutes—automatically—at the touch of a button.

Multiple drilling problems, complex or simple, are easily solved with flexible Gardner-Denver air tools. Number of holes, different hole sizes, angles or drilling depths present no problem. A specially designed fixture with proper components from the Gardner-Denver air tool line can be engineered to fill every practical need.

Gardner-Denver can design and build you a complete special machine or we can work with your engineers to develop a fixture for your needs . . . help you select air tool components to meet exacting requirements. Get in touch with your Gardner-Denver air tool specialist soon.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

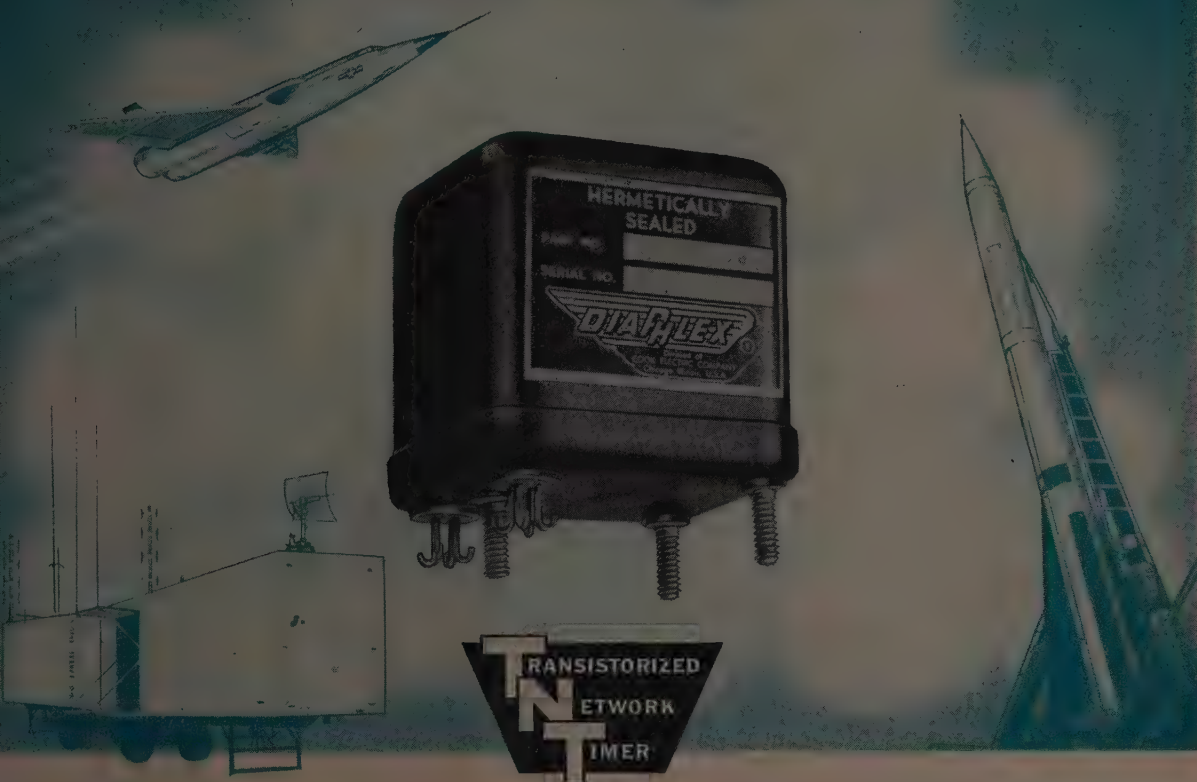
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Write in No. 89 on Reader Service Card at start of Product Review Section

SPACE/AERONAUTICS

For Rocket, Aircraft, and Ground Support

TELEMETERING, INTERLOCK, CONTROL, SEQUENCING, TIMING,
ARMING AND COMMUNICATIONS



A CLOCK WITH NO MOVING PARTS

The Transistorized Network Timer is designed for accurate sequential operation, as an interval timer, or use as an initial time delay in "warm-up" circuits, or step switching, safety interlock applications and timing delay circuits.

This timer features accurate settings from 1 to 60 seconds held to $\pm 5\%$ over the environmental range. Contacts are instantly resettable in less than .020 seconds. The unit will operate in tolerance from 18

to 29 VDC; other volt ranges are available. Ambient temperature may vary from -55 to $+125^{\circ}\text{C}$, vibration 15g's to 2000 CPS, shock 50g's 11 ± 2 milliseconds. Designed to conform to MIL-R-25018, Class B, Type II, Grade 3 as outlined above, this network timer has two pole double throw contacts rated 2 amps. resistive, 1 amp. inductive at 28VDC. The unit volume is $4\frac{1}{2}$ cubic inches and weight 4.5 ozs. This timer uses a transistor controlled RC circuit with no moving parts.

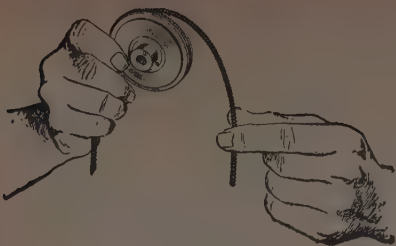


Cook Electric Company

2700 SOUTHPORT AVE., CHICAGO 14, ILLINOIS

DIAPHLEX—Aircraft Components and Accessories. COOK RESEARCH LABORATORIES—Basic & Applied Research. INLAND TESTING LABORATORIES—Qualification, Environmental, Reliability and Radiation Testing. MAGNILASTIC—Expansion Joints and Large Scale Metal Fabrications. WIRECOM—Wire Communication Protection & Distribution Equipment. ELECTRONICS SYSTEMS DIVISION—Engineering and Production of Electronic Gear. AIRMOD—Modernization, Modification, and Repair of Aircraft. NUCLEDYNE—Engineering and Design of Highly Complex Type Facilities. CINEFONICS, INC.—Motion Picture Production. CANADIAN DIAPHLEX, LTD.—Aircraft Components and Accessories.

Write in No. 90 on Reader Service Card at start of Product Review Section



A new key to Accuracy...

IN JET ENGINE, MISSILE AND AIRCRAFT CONTROL LINKAGES

The unusual cable shown above is Teleflex—the unique “flexible rack” that is helping to solve mechanical motion problems in the control of jet engines, missiles and aircraft.



HI-TEMP mechanical feedback control linkages operating at temperatures exceeding 1200°F.

HI-EFFICIENCY control systems comparable to tension cable systems... but at 1/9th the space, up to 60% less weight. Operating on every major aircraft in the country.

- No external moving parts...
- Perfect pressure seal—no special fittings required...
- Natural thermal loop—no special provisions necessary to compensate for temperature changes...
- The ultimate in minimum lost motion...

Teleflex tubular conduit, routed along contours and around obstructions, guides the cable to remote locations, duplicating the motion at both ends of a system.

DESIGN ENGINEERS—
For complete engineering data—send to Teleflex Incorporated, Church Rd., N. Wales, Pa., for your copy of Catalog 400.



Write in No. 91 on Reader-Service Card

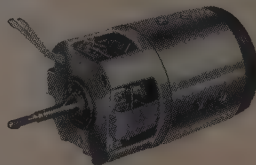
PRODUCT REVIEW

LINEAR ACTUATOR has 1800-lb rating

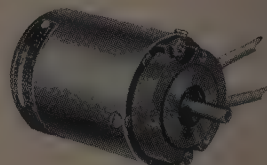
A 26-V dc linear actuator that operates under a normal load of 860 lbs at a .28-in./sec rate and has a maximum load rating of 1800 lbs has been designed by Hoover Electric Co., Dept. S/A, Hangar 2, Port Columbus Airport, Columbus 19, O. The Model D-1890, which has a 2.50-in. basic stroke that can be lengthened or shortened, is useful in a wide range of aircraft, missile, ordnance and industrial applications.

Features include a radio noise filter, adjustable travel limit switches, integral thermal overload protection, positive non-jamming mechanical stops, and adjustable self-aligning end fittings. The actuator has a building-block construction and is designed for efficient operation through a wide temperature range, as well as for excellent high-altitude and high-temperature performance.

Write in No. 129 on Reader-Service Card
more on page 200



24 Volt DC motor for operation submerged in jet fuel for booster pump drive. Frame 4 x 1½



Six-pole 400 cycle AC motor for electronic cooling in missile control equipment. Frame 1½ x 1¼



Totally enclosed fan-cooled 27 volt DC motor for pump drive. Frame 2 x 1½



24 Volt DC fuel valve actuator incorporates gear train torque-limiting clutch and limit switches. Frame 1½ x ¾

Thorough study by our engineering department of your product and its operating conditions is the first step in designing a Lamb Electric motor that will assure required dependability.

The next step is translating this information into a motor design having the electrical and mechanical characteristics needed for your particular application.

We then custom manufacture the motor on a volume basis to obtain high quality, uniformity and the most favorable cost.

May we discuss these advantages of Lamb Electric motors with you?

THE LAMB ELECTRIC COMPANY • Kent, Ohio

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Co. Ltd.—Leaside, Ontario

Write in No. 92 on Reader Service Card at start of Product Review Section
SPACE/AERONAUTICS

the first real "BREAK" for airborne harnesses

THE ALL NEW AMP

HELICON

CONNECTOR



FEATURES

- helical construction imparts a connection so firm that a special A-MP tool is required to connect and disconnect.
- "o" ring and metal wire-insulation ring make moisture-tight seal
- wiping action cleans pin and socket for assured maximum conductivity
- positive wire-stops prevent over-insertion of stripped conductor

FEATURES

- serrations inside barrel assure maximum crimp-contact between barrel and conductor
- inspection ports permit examination of conductors in barrel
- environmental proofing: moisture resistant, corrosion resistant, vibration and shock resistant

Never before has such a unit been available—a reliable, pre-insulated "manufacturing break" for aircraft and missile harnesses. Designed as a quick connect/disconnect for all high-reliability circuits, the all new AMP Helicon Connector is completely environmental-proofed and fully pre-insulated. Equally important, it requires a special A-MP tool to connect and disconnect, thereby preventing rampering and unintentional breaks in circuits.

The Helicon Connector can be attached to airborne circuit wires with remarkable speed and ease ... permits multiple connect/disconnects without harm to unit ... offers the highest reliability.



This is the product that the Avionics Industry has needed for years. There is nothing else on the market like it. Write for more information.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

Write in No. 93 on Reader Service Card at start of Product Review Section

AIR COMPRESSOR and VACUUM PUMP

TO MEET EXTREME AMBIENT REQUIREMENTS

Oil-Free, Self Lubricated —

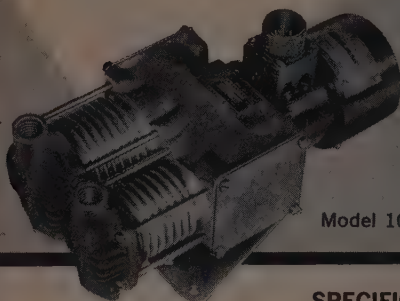
Qualified For 1,000 Hrs. Min. Life

Model 100-797-3 (shown below with specs.) operates efficiently within an ambient temperature range of minus 65°F to plus 200°F... meeting exacting customer and military specifications. This model is representative of a series of similar units designed and developed by Great Lakes to satisfy special requirements.

ATTENTION PROJECT GROUPS & SYSTEMS ENGINEERS!

Great Lakes can save you time and money by incorporating existing units in your design plans at an early stage. You will find that our Engineering, Designing, Testing, and Production Ability will augment your own facilities.

HIGH QUALITY MOTOR-DRIVEN AIR PUMP DESIGNED FOR USE IN AIRBORNE AND GROUND SUPPORT EQUIPMENT



Model 100-797-3

SPECIFICATIONS:

COMPRESSOR CAPACITY025 PPM at 30 PSI
Absolute Outlet with 7 inches Hg. Absolute Inlet Pressure

VACUUM CAPACITY . . . Will reduce 800 Cubic Inch Volume from 29.92 Inches Hg. Absolute to 0.5 Inches Hg. Absolute in 2 minutes with Outlet Discharging to Sea Level.

DUTY CYCLE Continuous

WEIGHT 8.75 Pounds



Absolute Ref. PRESSURE SWITCHES

4,000 PSI HYDRAULIC PUMPS

Motor-Driven FUEL PUMPS

Motor-Driven COOLANT PUMPS

Some of the complete line of products designed and manufactured at Great Lakes.

Write today, for complete information on Great Lakes PNEUMATIC-FUEL-HYDRAULIC Components. An experienced Sales Engineer is available to discuss your requirements.

GREAT LAKES

MANUFACTURING CORPORATION

4223 Monticello Boulevard • Cleveland 21, Ohio

Write in No. 94 on Reader-Service Card

PRODUCT REVIEW

PUMPS

operate with any fluid

Insensitivity to the type of fluid used is featured in a new line of piston-type hydraulic pumps for aircraft and missile flight control systems, says Pesco Products Div., Borg-Warner Corp., Dept. S/A, Bedford, O. High-temperature operation, increased reliability at higher operating speeds and a minimum of rotating parts are among other design features.

The constant pressure, variable displacement pumps have either single or dual pumping elements, and they are designed to run at speeds up to 7500 rpm. They are recommended for use with fluid temperatures up to 550 deg F. Capacities offered by the line are from three to 27 gpm, with system pressures generally 3000 psi. The dual unit type may be used in 4000-psi systems.

Write in No. 139 on Reader-Service Card

FLIGHT SIMULATOR

has high response

This high-response flight simulator, which accurately tests airborne electronic components over a full range of flight patterns, offers a wide range of rates and amplitudes because of its unique design, says Task Corp., Dept. S/A, 1009 E. Vermont Ave., Anaheim, Calif. The ranges extend from .004 to 240 deg and from 0.01 to 30 cps about either of two axis.

The low threshold device, which has been delivered to Convair, accommodates components as large as 12x12x14 in. and as heavy as 50 lbs, and it will subject them to accelerations of 6×10^4 deg/sec.² Extremely small friction allows controlled testing of gyro stability, and total system error is less than 15 sec of arc. The complete equipment includes a 60-hp, 1500-psi hydraulic unit and an electronic control system. One- and three-axis models are also available.

Write in No. 140 on Reader-Service Card

MILLIAMMETER

is time-saver

The Model 428A dc milliammeter is particularly useful in transistor and computer work and in low impedance circuits, says Hewlett Packard Co., Dept. S/A, 275 Page Mill Rd., Palo Alto, Calif. The device has a pen-sized probe, which clips around a wire without interrupting or loading the circuit; breaking and resoldering leads are unnecessary operations.

The device has full-scale current ranges from three ma to one amp in six steps. Accuracy, which is unaffected by line voltage changes, instrument aging, or the effects of the earth's magnetic field, is plus or minus three per cent, ± 0.1 ma. The instrument can measure dc currents in the presence of ac and make extremely low-current-level measurements.

Write in No. 141 on Reader-Service Card

PREAMPLIFIER

offers high performance

A dc coupling preamplifier, the Model 450-1800, for use with optical oscillographs, tape recorders, oscilloscopes, and other devices, offers high performance with either single-ended or balanced signals, says Sanborn Co., Dept. S/A, 175 Wyman St., Waltham 54, Mass. Frequency response is zero to ten kc, and linearity, $\frac{1}{4}$ per cent.

Front panel controls include sensitivity, position, attenuator, balance in-out switch, and input and output connectors, as well as others. Plus or minus zero suppression to 20 times full scale voltage is included. (The instrument is offered in a model that does not include zero suppression). A three-stage circuit has a cathode follower input and output, and a second stage push-pull transistor amplifier for overall gain. A 50-mv input produces one V under maximum output load conditions.

Write in No. 249 on Reader Service Card

PUMP

prevents turbine stall



The standard 3909 Series variable delivery pump, which incorporates torque limiting features, can be used with any air turbine drive where torque output is a function of speed, says Vickers, Inc., Dept. S/A, Detroit 32, Mich. The unit was originally designed for emergency ram air hydraulic and alternator drive applications.

The pump will prevent turbine stall due to pump torque requirements at start and at low air speeds. It is recommended for operating pressures to 3000 psi and speeds to 8000 rpm, and under those conditions, its capacity is 12.-2 gpm. It produces full outlet pressure at all turbine speeds. Pump torque demand always remains within the turbine's capacity to supply torque. The unit, which weighs 11.8 lbs, has a 95 per cent volumetric efficiency and a 92 per cent overall efficiency.

Write in No. 250 on Reader-Service Card

CAPACITORS are special types

Polystyrene capacitors are available in special types with zero temperature coefficient and stability of 0.008 per cent. Other coefficients available such as 40 PPM/deg C. Any capacitance value from 0.05 mfd. up, available to a tolerance of 0.1 per cent in any solder sealed metal container. Units for ac operation with silicone impregnation available up to 20KV, says Melray Electronic Mfg. Corp., Dept. S/A, 38 Austin St., Worcester, Mass.

Standard types in CP70 cans, bathtub either adjustable or fixed, or metal tubulars in very small sizes available with temperature coefficient of -100 PPM/deg C and stability of 0.04 per cent from stock, per bulletin PC-1000, available upon request.

Write in No. 251 on Reader-Service Card
more on page 204



DAGE relies on new Proto-Circuits Division for printed wiring prototypes

Dage Television needed printed wiring prototypes—in a hurry. The project: the 1st Airborne Transistorized MIL Qualified TV System, for automatic, fully stabilized control of Photo Reconnaissance Cameras.

Dage's choice: PROTO-CIRCUITS Division of PHOTOCIRCUITS.

Only PHOTOCIRCUITS offers you such a complete, separate prototype facility. PROTO-CIRCUITS' streamlined organization—from design through tooling—cuts paperwork and overhead to the bare minimum. You get *fast service at low cost*, whether you're next door or across the country.

You get *better* prototypes, because PROTO-CIRCUITS uses the same highly refined production techniques utilized by PHOTOCIRCUITS.

The transition from prototype to production is a smooth one, free from awkward, costly mistakes and misunderstandings. PHOTOCIRCUITS' unique and unequalled production capacity assures a steady, on-time flow of boards, regardless of quantity.

Dage made the logical choice—based on high quality, low cost, fast service. For the same reasons, you too should contact PROTO-CIRCUITS for your prototype needs. Write or call Department 1135 for full information today.



Photocircuits
CORPORATION

GLEN COVE, NEW YORK

PHONES

GLEN COVE 4-8000 FLUSHING 7-8100

CABLE

PHOCIRCO

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This is the JFC-25 control, installed on 15,000 lb.-thrust class engines in the F8U-3, F-106, 707 and DC-8 aircraft.

Jet Engine Controls... by **Hamilton Standard**

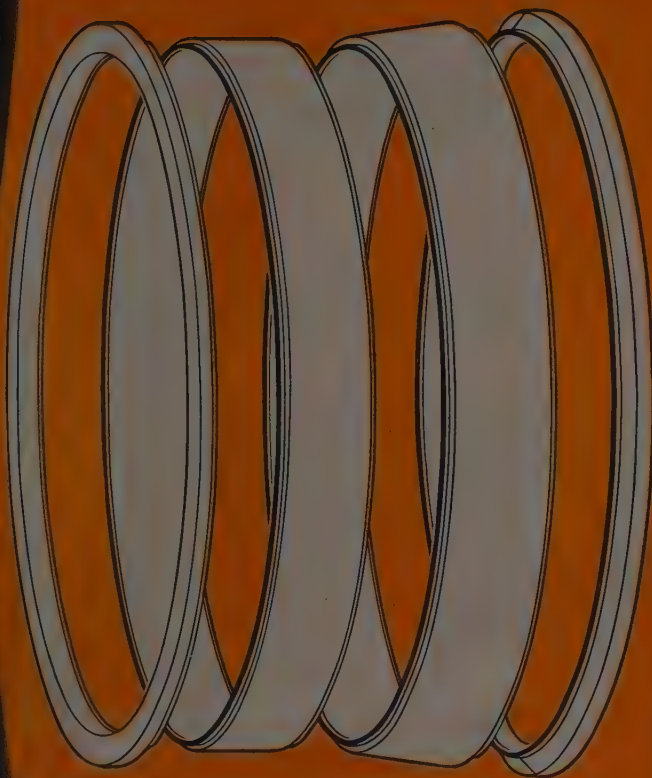
Fighters or bombers, transports or missiles . . . today's leading aircraft get top performance with Hamilton Standard jet engine controls . . . currently manufactured in 5 basic types, with models for every power category from 2000 to 30,000 pounds-thrust. More than 20,000 of these controls are now in service . . . on more than 16 types of aircraft, both military and commercial. Advanced designs in environmental control systems, starters, pumps and other specialized equipment make Hamilton Standard *a major contributor to progress in the fast-changing world of flight.*



HAMILTON STANDARD

Windsor Locks, Connecticut

ENGINE CONTROLS • FLIGHT CONTROLS • PROPELLERS • STARTERS
ENVIRONMENTAL CONTROL SYSTEMS • VALVES • PUMPS



The two outside flash butt-welded rings were joined to the inner flash butt-welded bands around the circumference by submerged arc welding. The two halves were then welded together to complete the assembly.

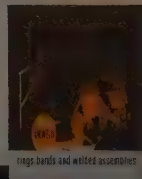
Tricky

Welded Fabrication Cuts Cost of this Precision Assembly

To reduce material and machining time, Amweld® produced this 340 lb. turbine casing as a 4-piece welded assembly. Four flash butt-welded rings were joined together by submerged arc welding. The material used was AMS-5723, a high temperature alloy. Amweld's know-how, gained from fabricating hard-to-weld metals, enabled their engineers to develop a satisfactory technique for producing these aircraft components in quantity. The result — assemblies which met all specifications — and a substantial reduction in cost for a large manufacturer of aircraft engines.

If you would like to obtain complete information on the capabilities of American Welding and how we can be of assistance to you — phone or write today. Our local representative will be happy to call and discuss your requirements.

HOW AMWELD® FLASH BUTT-WELDED RINGS ARE PRODUCED. Write today for new 20-page illustrated booklet.



THE AMERICAN WELDING & MANUFACTURING CO.

450 Dietz Road • Warren, Ohio

AMERICAN WELDING

Write in No. 96 on Reader Service Card at start of Product Review Section

COMPUTER DIODE has fast switching rate

A germanium diode has what is believed to be the world's fastest switching time—.9 musec, says Transatron Electronic Corp., Dept. S/A, Wakefield, Mass. The S570G is thus suitable for use in extremely high-speed transistorized circuitry.

It is intended for critical computer applications at normal transistor bias levels. After a ten-man forward current, the stored charge is under that of a three-mmF capacitor at six V. The S555G, another fast diode, is specified at six musec and offers better dc characteristics.

Write in No. 142 on Reader-Service Card

VIBRATION MOUNTS resist temperature effects

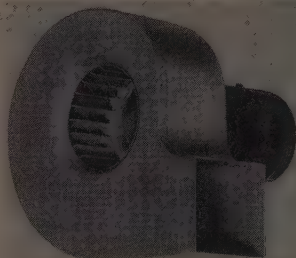
The bonded rubber vibration and shock control mountings in this line have the ability to withstand temperature extremes with minimum changes in physical properties, says Lord Mfg. Co., Dept. S/A, 1635 W. Twelfth St., Erie, Pa. They can operate efficiently from -65 to +300 deg F.

Transmissibility at resonance is under three at 68 deg F and under 3.5 at 300 deg F. The vibration mountings utilize an oil and ozone-

resistant elastomer with high tensile strength and good flex life.

Write in No. 144 on Reader-Service Card

BLOWERS are efficient

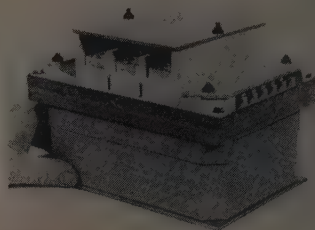


Centrifugal blowers that may be obtained in from two to nine-in. dia have been designed for cooling electronic equipment in aircraft, missile, radio and computer service, says The Torrington Mfg. Co., Dept. S/A, Torrington, Conn. Air delivery range is from 20 to 2000 cfm, depending on impeller size and motor speed.

Input power for the efficient, low pressure blower is provided by either ac, dc or 400-cycle aircraft motors. The unit weighs under two lbs.

Write in No. 143 on Reader-Service Card

CIRCUIT BREAKER operates at 600 deg F

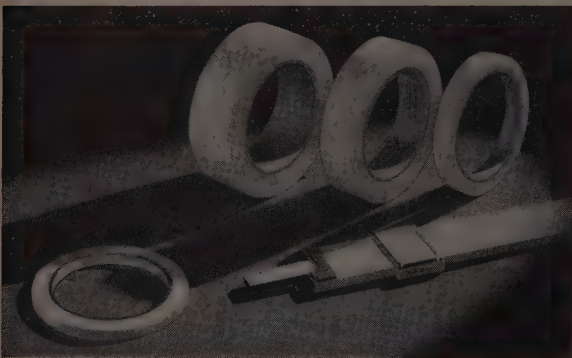


This new aircraft circuit breaker will function over -65 to +600-deg F ambient temperature range, and at altitudes up to 75,000 ft, according to Westinghouse Electric Corp., Dept. S/A, Lima, O. The latch-type breaker has a rating of 225 amps at 480 V ac, 400 cycles, three phase.

Maximum current interrupting ability is 4000 amps. In dc applications, the device operates at 250 V dc and will carry 500 amps for 15 min. Contact closing time of the 18.5-lb unit is 0.05 sec, maximum, and trip time is 0.01 sec, max. The breaker has a life of 1000 hrs, with 5000 interruptions at rated current.

Write in No. 145 on Reader-Service Card

more on page 208



TEMP-R-TAPE® pressure-sensitive TEFLON* tapes for Class H & C insulation, non-stick or chemical resistant facing

Temp-R-Tapes, Teflon with a silicone polymer adhesive, provide dielectric strength up to 2750 v/m, low power factor, a temperature range of -100°F to 500°F (-75°C to 250°C) and a slippery, low friction or chemical resistant surface. Easy-to-apply, just press in place. Temp-R-Tapes are "called out" for many electrical and electronic insulating applications, aircraft and general industrial mechanical applications. 1/4" to 12" wide, .002" to .013" thick. From stock.

* du Pont T.M.

FREE SAMPLE and data . . . write, phone or use inquiry service.

A PRODUCT OF **CHR** THE CONNECTICUT HARD RUBBER CO., NEW HAVEN 9, CONN.

Write in No. 97 on Reader-Service Card

FOR LEAK-DETECTION DEVICES



NITROUS OXIDE

EASILY
SNIFFS OUT
MICROSCOPIC
LEAKS

Infrared determination of nitrous oxide provides a safe, sensitive and flexible method of leak detection. This method is not affected by usual atmosphere components such as moisture, carbon dioxide and hydrocarbons. In addition, nitrous oxide will not harm pieces being tested and is more economical than other gaseous agents.

OHIO NITROUS OXIDE: ODORLESS AND INERT • NONTOXIC
• NONCORROSIVE • NONFLAMMABLE • ECONOMICAL

FREE TECHNICAL AID is available in the use of nitrous oxide for leak detection. For further information, please request the following bulletins:

- 1A Chemical, Physical and Pharmacological Properties of Nitrous Oxide with Results of Corrosion Tests
- 1B Gas Service Equipment for Nitrous Oxide Supply



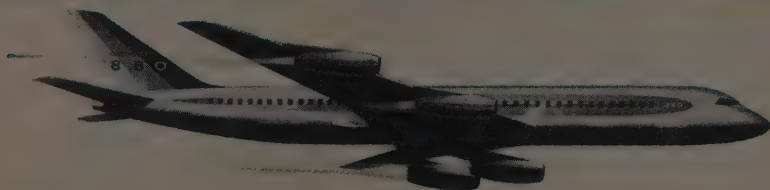
Ohio Chemical

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.

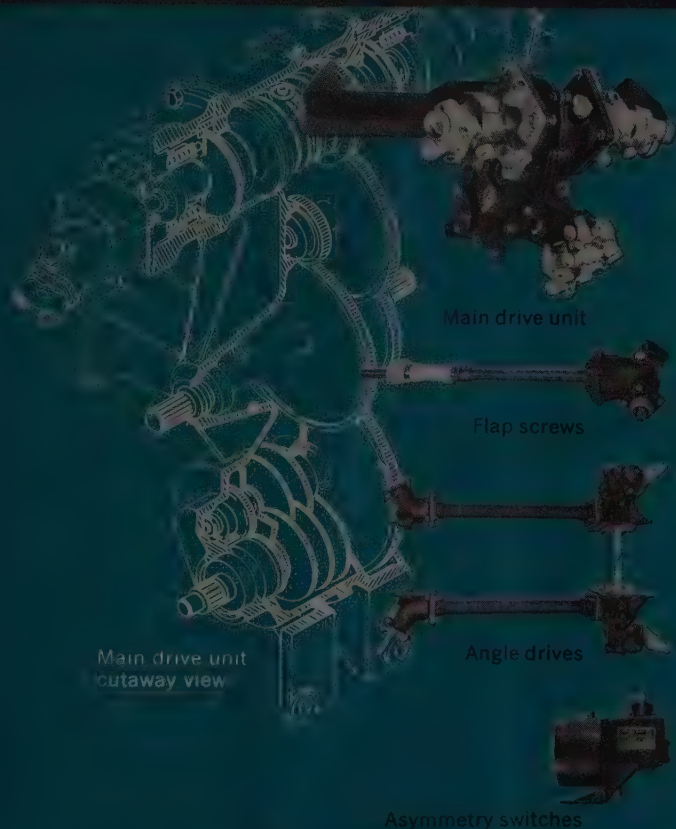
(A Division of Air Reduction Company, Incorporated) **ARCO**
MADISON 10, WISCONSIN

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SPACE/AERONAUTICS



WESTERN GEAR designs and builds wing flap control system for **CONVAIR 880**



The newly named Precision Products Division of Western Gear Corporation has launched an intensified program of developing systems for the aircraft industry. Stepped-up research, creative engineering, testing and manufacturing facilities put this division in the forefront of the nation's leading suppliers.

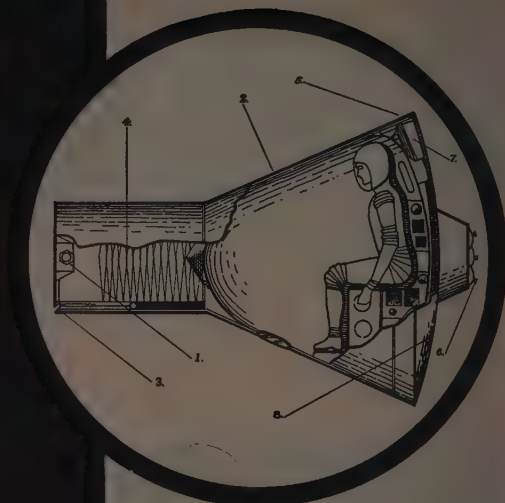
Most recent development is the wing flap control system for the Convair 880 jetliner. Western Gear carried the entire completely-integrated system through design, testing and fabrication, delivering the units shown here as well as torque tubes, driveshafts, motors and other components.

Complete reliability is the engineering and manufacturing *plus* that goes into every Western Gear component and system. Learn how this fast-moving company can help you with any needs in aero mechanics.

For full information, write today to:
WESTERN GEAR CORPORATION
Precision Products Division
P.O. Box 182 • Lynwood, Calif.



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1. Horizon Scanner
2. Entrance Hatch
3. Pitch & Yaw Jets
4. Packed Parachute
5. Roll Jets
6. Retro-Rockets
7. Inflatable Landing Impact Bag
8. Heat Shield

NASA Manned Satellite Capsule

NASA blueprint for the future

PROJECT MERCURY

At this moment NASA engineers and scientists are hard at work to make Project Mercury a reality. And in time a manned satellite will become reality . . . the result of outstanding professional contributions in many disciplines. This program to place man in space is typical of the projects and goals of NASA, whose responsibility it is to direct and implement U.S. research efforts in aeronautics and the exploration of space, for peaceful purposes and the benefit of all mankind.

NASA offers unique opportunities in basic and applied research in aeronautics and space technology—

For Engineers:

Aeronautical, Engineering Physics, Electronic, Mechanical, Electrical, Metallurgical, Chemical, Civil, Naval Architects.

For Scientists:

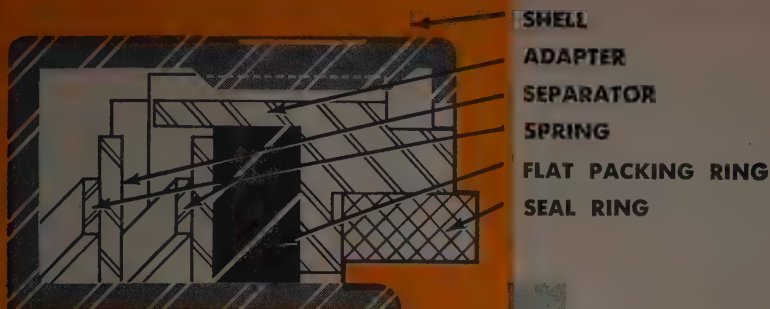
Astronomers, Physicists, Mathematicians, Chemists, Metallurgists.

Please address your inquiry to the Personnel Director of any of the following NASA research centers:

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- Ames Research Center, Mountain View, California
- Lewis Research Center, Cleveland, Ohio
- High-Speed Flight Station, Edwards, California
- Beltsville Space Center, 4555 Overlook Ave., Wash., D. C.

(Positions are filled in accordance with Aeronautical Research Announcement 61B)

NASA National Aeronautics and Space Administration



SHELL

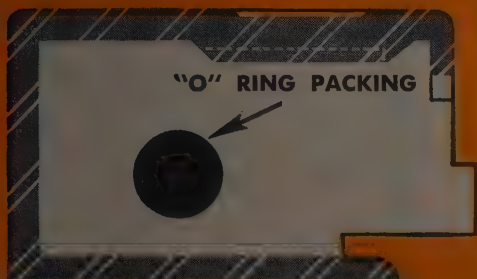
ADAPTER

SEPARATOR

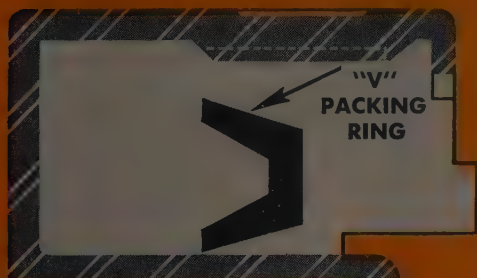
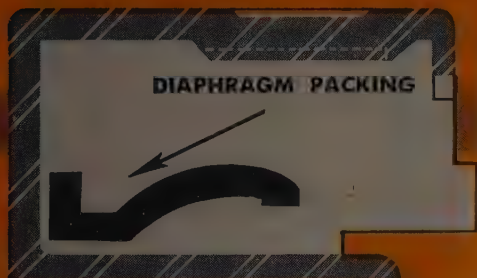
SPRING

FLAT PACKING RING

SEAL RING



"O" RING PACKING

"V"
PACKING
RING

DIAPHRAGM PACKING



WEDGE PACKING RING

VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

GITS

*Extra Flexibility For
Your Seal Applications*

ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope — with your choice of the five seal packing arrangements illustrated at left — permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements of the aircraft and missile industry.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information.

GITS BROS. MFG. CO.

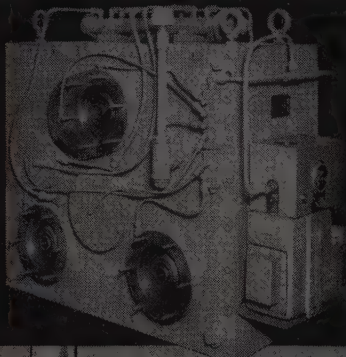
1850B South Kilbourn Avenue • Chicago 23, Illinois

NEW! Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.

For high speed testing

S·N

**SPEED
INCREASER
UNITS**



*designed
and built
to your
specifications*

S-N SPEED INCREASER GEAR UNITS have wide application on aviation industrial test equipment. They are the product of transmission engineers with over half a century of experience. Standard units are available with a wide range of gear ratios and output speeds. S-N will also design and build units for special or unusual requirements.

Series 4070, illustrated, is used for fuel pump testing. It has a capacity of 400 HP at 1150 RPM. Each of the three output pads deliver the full rated horsepower. Two have output speeds of 4215 RPM, and the other 15,800 RPM. Complete information promptly furnished upon request.

SNOW-NABSTEDT

Transmission Engineers
FOR OVER HALF A CENTURY
THE SNOW-NABSTEDT GEAR CORP., HAMDEN, CONN.



Write in No. 103 on Reader-Service Card

PRODUCT REVIEW

**POTENTIOMETER
is extremely precise**

Missile and aircraft flight controls and instrumentation should benefit from a new precision, multiturn, miniature potentiometer, says Components Div., Litton Industries, Dept. S/A, 5873 Rodeo Rd., Los Angeles 16, Calif. The model MD 09-10 can guarantee independent linearity to ± 0.015 per cent and resolution to 0.0085 per cent.

The $\frac{3}{8}$ -in. dia unit has a ceramic core, a drawn-metal case with O-ring seal, and stainless steel ball bearings protected with a Teflon seal.

Write in No. 130 on Reader-Service Card

**WAVEGUIDES
reduced in weight**



A very light jacket of aluminum tubing, and aluminum flanges have been combined into flexible waveguide assemblies capable of weight savings up to 60 per cent, says Airtron, Inc., Dept. S/A, 1096 W. Elizabeth Ave., Linden, N.J. Flexaguides resist ozone and corrosive action, and they can be made in complex bend configurations without expensive tooling.

Flexaguides or jacket can also be supplied in combination with other tubing or jacket materials.

Write in No. 131 on Reader-Service Card

**TRAINER
shows servo operation**

The circuit operation of either a closed or open loop positioning servo system is shown visually by a servo system trainer ideal for lectures and demonstrations, says Kearfott Co., Inc., Dept. S/A, 1378 Main Ave., Clifton, N.J. Two cases are used to hold a variety of components, including control transmitter, control transformer, vacuum tube servo amplifier with B \pm supply, motor generator, and others.

The portable device uses large, illuminated indicators to continuously display angular position of the CX, CDX, and TR. A plexiglass window permits observation of the servo gear train assembly during operation.

Write in No. 132 on Reader-Service Card
more on page 212

Here's
how Alcoa
helps you
design and
make
it...

You get more than just 16 ounces of metal in every pound of Alcoa® Aluminum. Here are eight important unmatched values that go with it:

- 1 Research Leadership, bringing you the newest in alloys and other applications.
- 2 Product Development by experienced specialists in your field of interest.
- 3 Process Development Labs for aid in finishing, joining and fabricating.
- 4 Service Inspectors to help solve production problems in your plant.
- 5 Quality Control to meet demanding standards and to match your special needs.
- 6 Availability, channeled through the nation's best-stocked aluminum distributors.
- 7 Factory-Trained Salesmen for vital, on-the-spot information.
- 8 Sales Administrators, constantly on call to service your orders.

Complete line of commercial aluminum in all forms, alloys, gages, tempers and job shop services.

MILL AND CUSTOM PRODUCTS

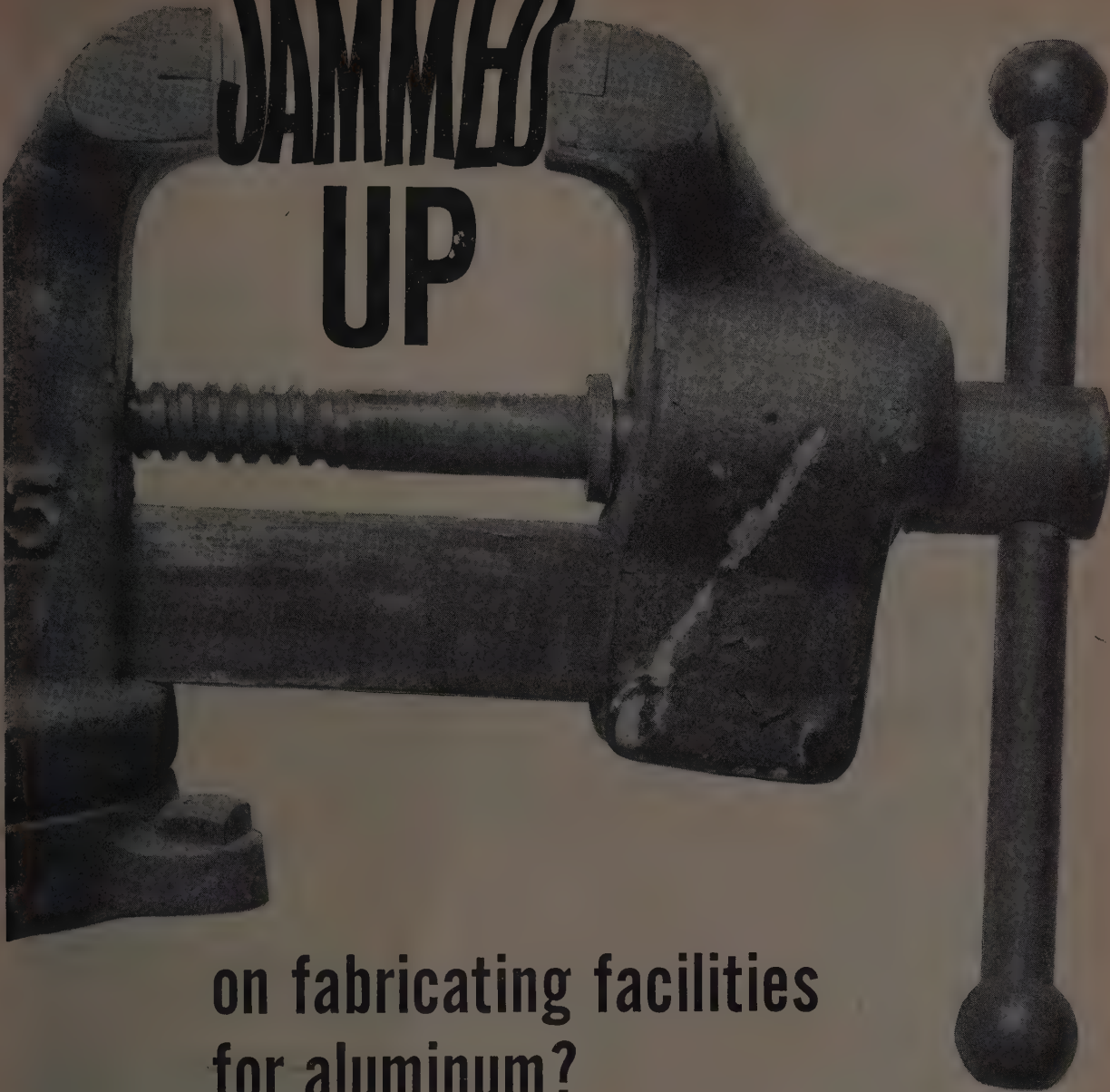
INGOT AND PIG • SHEET • PLATE
WIRE • ROD • BAR • TUBE
ELECTRICAL CONDUCTORS
STRUCTURAL SHAPES
CHEMICALS AND POWDER
ROOFING • FOIL • FASTENERS • PIPE
CASTINGS (Sand, Die, Permanent Mold)
IMPAIRS • EXTRUSIONS • FORGINGS
MAGNESIUM CASTINGS & FORGINGS
SCREW MACHINE PARTS

JOB SHOP

FORMING • WELDING • FINISHING
FABRICATION AND ASSEMBLY



Write in No. 104 on Reader-Service Card
SPACE/AERONAUTICS



JAMMED UP

on fabricating facilities for aluminum?

Let ALCOA'S JOBBING DIVISION Be YOUR Subcontractor!

WANT TO stretch your aluminum fabricating facilities, particularly during peak production periods?

THEN CALL on Alcoa's "custom-service for *manufacturers*"—the Alcoa Jobbing Division. From a single, tiny component to the most complex subassembly, consider Alcoa's Jobbing Division for any part of an aluminum fabricating job. In the field of aircraft and missile components, especially, Alcoa's facilities and experience are unmatched anywhere in the world.

COST . . . ? Frequently *less* than your own cost-accountants would report for a do-it-yourself job. For

Alcoa *already* has the major facilities for production—plus the facilities and skills for tooling-up at rock-bottom costs.

WANT TO know more . . . ? Write Aluminum Company of America, 2057-B Alcoa Building, Pittsburgh 19, Pa., for 16-page booklet on the available facilities of Alcoa's Jobbing Division. Facilities at *your* service . . . for welding, rolling, brake-forming, bending, spinning, finishing, testing and other services. You'll be surprised how much Alcoa can help you *lighten* your load!



Your Guide to the Best in Aluminum Value



Write in No. 105 on Reader Service Card at start of Product Review Section

THE DIVISIONS OF THOMPSON RAMO WOOLDRIDGE INC.



RAMO-WOOLDRIDGE

While it is now a division of **Thompson Ramo Wooldridge Inc.** instead of a separate corporation, **Ramo-Wooldridge** remains an integrated organization for research, development, and manufacture of electronic systems for military and commercial applications. R-W's military work is covered by thirty-four contracts with the Army, Navy, Air Force, and other government and industrial organizations. These support a broad technical and—in some cases—manufacturing program in such varied fields as Electronic Reconnaissance and Countermeasures; Microwave Techniques; Infrared; Analog and Digital Computers; Air Navigation and Traffic Control; Antisubmarine Warfare; Electronic Language Translation; and advanced Radio and Wireline Communication.

In the commercial field, the well-known RW-300 industrial process control computer and associated equipment—the basis of the expanding business that **The Thompson-Ramo-Wooldridge Products Company** is doing with process industries—was developed and is manufactured by the Ramo-Wooldridge division.

Men, machines, and manufacturing know-how from other TRW divisions will be added as needed to build up the growing production strength of the Ramo-Wooldridge division. In other ways, too, the availability of the special skills and facilities of the rest of the corporate family will broaden the services R-W can offer to its customers. However, R-W's major systems work will continue to be done in an organizational framework that brings the engineering and manufacturing groups into close-knit project teams in the division's own integrated development and manufacturing facilities in both Los Angeles and Denver.

Ramo-Wooldridge is production-oriented in the sense that its end objective is the manufacture and sale of equipment. However, because of the highly technical nature of its product lines, the R-W division will continue to give unusual emphasis to maintaining a high degree of professional scientific and engineering competence.



Thompson Ramo Wooldridge Inc.

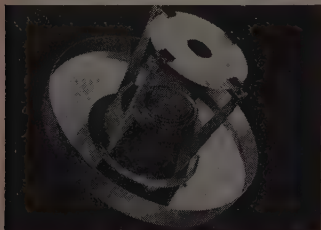
MAIN OFFICES
CLEVELAND 17, OHIO
LOS ANGELES 45, CALIFORNIA



The completely transistorized RW-30 airborne digital computer has a volume of 4.19 cu. ft. and weighs only 203 lbs., including power supply



Ramo-Wooldridge is responsible for advanced electronic sub-systems development for application with both current and projected missile programs



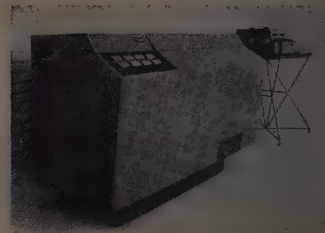
Important infrared "search and track" equipment is now being developed by Ramo-Wooldridge for applications in modern U.S. Military aircraft



R-W is one of the major participants working with the Boeing Airplane Co. Systems Management Office on the U.S. Air Force Dyna-Soar project



New type of radar data processing system developed by R-W materially increases the capabilities of ground defense radar



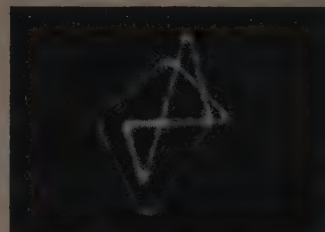
The RW-300 digital control computer has broad applications in automatic process control, data reduction and test facility operation



Systems are being developed for the ground processing and interpretation of photographic and other data collected by aerial reconnaissance devices



The Military and Ramo-Wooldridge are studying the use of automatic data processing techniques



In research laboratory studies at Ramo-Wooldridge, electrically-charged particles are contained and supported in a vacuum by an alternating electric field



STEPS IN THE RACE TO OUTER SPACE

Mars Snooper

This nuclear-fueled reconnaissance craft is preparing to land on Mars' outermost satellite, Deimos—12,500 miles away from the "red planet" (center) and 35 million miles away from the Earth. Deimos' gravitational pull is so slight that a featherlight landing could be made, and a take-off could be accomplished with little more than a shove of the pilot's foot! (At Deimos' orbital speed, such a push would start the ship back to Earth at 3000 miles per hour.)

Our spaceship is designed to fly in two directions—nose first as a space rocket and tail-first as a ramjet airplane. Propulsion for both is provided by a single

atomic heat source, reacting with hydrogen for rocket thrust, and with atmosphere to power the ramjets.

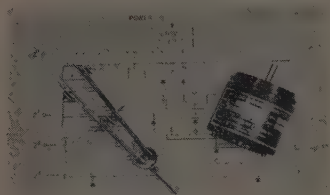
Travel to Mars, braking for landing, take-off and re-entry are accomplished by rocket-thrust. As the ship approaches the Earth's atmosphere, it assumes a tail-first attitude. The "petal doors" enclose the rocket nozzle, and the ship is transformed into a high speed, ramjet airplane with M-shaped wings. Control fins are located in the nose of the craft, near the crew's quarters.

ENGINEERS • SCIENTISTS

ARMA needs key men to augment a broad research program in missile guidance and space technology. As designer and developer of all-inertial navigation systems for TITAN and ATLAS ICBM's, **ARMA** provides a stimulating atmosphere where creative talents can develop. Write to E. C. Lester, Professional Placement, SP-2, **ARMA** Division, Garden City, N.Y. A Division of American Bosch Arma Corporation.

AMERICAN BOSCH ARMA CORPORATION

AIRBORNE ENCODER is "smallest available"



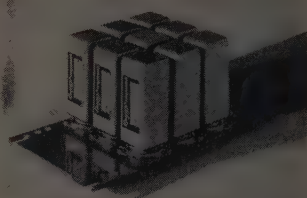
Brush selection is automatically performed within the encoder of

the ADC-BNRY airborne shaft encoders. Electronics otherwise required for double brush V-scan systems are thus eliminated, says Norden Div., United Aircraft Corp., Dept. S/A, Wiley St., Milford, Conn.

The encoders, believed to be the smallest available, are said to attain exceptionally long, noise-free life by preventing commutation of load currents on the disc. An error-detecting scheme detects and rejects erroneous readings.

Write in No. 133 on Reader-Service Card

DIGITAL CIRCUITS are fully encapsulated

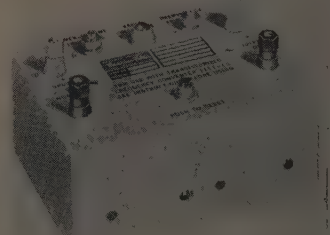


Transistor digital circuits that are fully encapsulated have been designed for a wide variety of functions, including flip-flops and counters, diodes and gates, parallel gates, non-inverting amplifiers, power drivers, level converters, blocking oscillators, and others. The circuits are designed for 100-kc operation, but permit operation up to 200 kc and, in some cases, up to 400 kc, says Epsco, Inc., Dept. S/A, 588 Commonwealth Ave., Boston, Mass.

The units are available in three temperature ranges: minus ten to +60 deg C; minus ten to +71 deg C; and -55 to +71 deg C. Style A mounts in nine and 14-pin miniature tube sockets, and Style B is for 15-pin in-line mounting.

Write in No. 134 on Reader-Service Card

CIRCUIT PROTECTOR is fast acting



A new fast acting circuit protector is designed for bench testing application, says Aeronautical Div., Robertshaw-Fulton Controls Co., Dept. S/A, 401 N. Manchester, Anaheim, Calif. Sensitive to applied dc voltage and to current drain, the overload trip levels are adjustable from 24 to 32 V dc and from three to five amperes. The unit is selflatching and after correcting any transient fault may be returned to normal operation by use of the reset button.

In operation, voltage sensing is achieved by use of a zener diode comparison with a portion of the output voltage. Current is determined by the voltage drop across a low-value resistor in series with the positive dc lead.

Write in No. 135 on Reader-Service Card

more on page 214

Wherever you
use compressed
air...

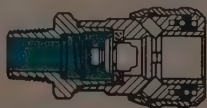
...just

PLUG IN THE POWER

with
HANSEN
Quick-
Connective
Couplings

As easy as plugging
in your electric shaver

To connect the Coupling, just push the Plug into the Socket—with one hand. Flow is instantaneous. To disconnect, push back sleeve on Socket. Coupling disconnects with instant, automatic shut-off of air.



Blue section shows how Socket, when disconnected, automatically shuts off air by leak-proof seal of metal valve against rubber valve seat.

Quick
Connection
and
Disconnection

Instant
Automatic
Flow or
Shut-Off



Write for Hansen Catalog

—a ready reference when you want information on couplings in a hurry. Lists complete range of sizes of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings.

Quick-Connective
Fluid Line Couplings for

AIR • OIL • GREASE • HYDRAULIC
FLUIDS • WATER • VACUUM • STEAM
OXYGEN-ACETYLENE-REFRIGERANTS
GASOLINE • COOLANTS • LP-GAS

Representatives in Principal Cities

THE HANSEN



MANUFACTURING COMPANY

4031 WEST 150TH STREET

CLEVELAND 25, OHIO

Write in No. 107 on Reader Service Card at start of Product Review Section



Forming and handling polished metal sheet can be speeded . . . rejects almost eliminated . . . by using "SCOTCH" Brand Masking Paper and tight-holding "SCOTCH" Brand Masking Tape. Applied prior to forming operations, such protective masks guard polished surfaces against scratches, die marks, staining—may be left on right through shipping if desired, yet removes easily and cleanly. Application can be kept up to production line speed by using "SCOTCH" Brand Apron Tapers to apply the tape to one or both edges of the paper as it is pulled from the roll. Fast, easy, economical . . . the cost-saving way to increase handling speeds on flat, polished metal stock.

When tape costs so little, why take less than "SCOTCH" Brand?

- "SCOTCH" is a registered trademark for the pressure-sensitive adhesive tapes of 3M Co., St. Paul 6, Minn. Export: 99 Park Ave., New York 16. Canada: London, Ontario.



... WHERE RESEARCH IS THE KEY TO TOMORROW

February 1959

NOW! from SIKORSKY AIRCRAFT

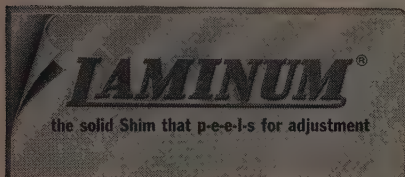
Proof Positive that **LAMINUM**[®]

LAMINATED SHIMS

Save Time! Save Money! Improve Quality!



● This technician is with Sikorsky Aircraft, Division of United Aircraft Corporation at Stratford, Connecticut. He is placing a 12½" diameter LAMINUM shim on an input assembly. In foreground are other LAMINUM shims. Notwithstanding extremely close assembly tolerances, Sikorsky saves time and cuts costs by using Laminum. No need for micrometer checking, no need for standby grinding or machining. Laminum Shims simply p-e-e-l for a thousandth fit, right at the job. That's why a long list of aircraft as well as missile and rocket producers benefit from the use of laminated shims of LAMINUM.



Laminum looks, acts like solid metal—yet quickly p-e-e-l-s to precision fit right at the job. In Brass, Mild Steel, Type 302 Stainless with .003" or .002" laminations. In Aluminum with .003" laminations or **NEW** with .002" laminations. Custom-made, Laminum Shims eliminate extra operations: no machining, no grinding, no stacking, no miking. And no grit between layers—ever!

Write in No. 109 on Reader Service Card at Start of Product Review Section

FREE! Actual sample of LAMINUM—also illustrated Engineering Data File. Write for your copy today.



EAST COAST
Home Office and Plant
5302 Union Street
Glenbrook, Conn.

WEST COAST
Sales Office
600 Sixteenth St.
Oakland 12, Calif.

PRODUCT REVIEW

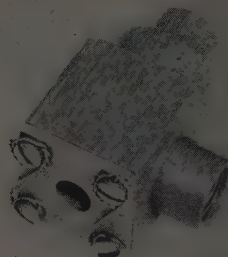
CAPACITORS have low capacitance

A capacitance as low as 60 mmf is available in a new group of voltage-sensitive ceramic capacitors, according to Mucon Corp., Dept. S/A, 9 St. Francis St., Newark 5, N.J. Capacitance may be decreased as much as 60 per cent by applying a dc potential up to 200 V.

Type LVSR has maximum sensitivity at room temperature, and LVSE has voltage sensitivity at about 70 deg C. The capacitors are housed in steatite tubes of about ⅜ in. dia and ⅞ in. length. The soldered-in leads are #26 gauge.

Write in No. 136 on Reader-Service Card

EXHAUST VALVE for high pressures



An exhaust valve for pneumatic brakes and other long-line pneumatic systems has an operating pressure of 1000 psi, says Walter Kidde & Co., Inc., Dept. S/A, 675 Main St., Belleville 9, N.J. A drop of air pressure upstream of the valve results in the rapid exhaust of downstream air.

The valve has a 0.10 flow factor and a -65 to +160 deg F range. It measures ⅞x1⅞x1⅞ in. and it weighs 0.1 lb.

Write in No. 137 on Reader-Service Card

REGULATOR mounts in jet intake

This annular oil temperature regulator fits integrally in the air intake of a missile's jet engine, says AiResearch Mfg. Div., The Garrett Corp., Dept. S/A, 9851 Sepulveda Blvd., Los Angeles 45, Calif. It creates no extra profile drag and cools hot engine oil by skimming off only the boundary layer of air passing through the engine intake.

The device is made of aluminum, except for stainless steel plumbing to carry oil flow. Inside diameter is 17 in. and weight is ten lbs.

Write in No. 138 on Reader-Service Card
more on page 218

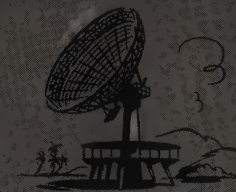
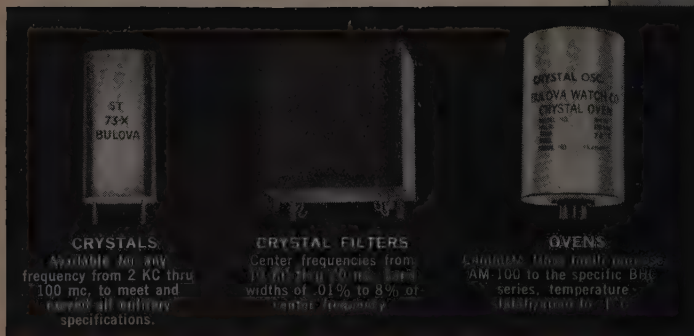


Infrared is one of many specialized electronic fields in which the Singer Manufacturing Company's Military Products Division is making substantial contributions. Through the integration of talent and facilities of H.R.B., Inc., Diehl Manufacturing Company, and Bridgeport, the Military Products Division offers a complete service from R&D, through engineering, and production. Write for complete details.



THE SINGER MANUFACTURING COMPANY
 Military Products Division • 149 Broadway, New York 6, N. Y.
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BULOVA

NUMBER ONE

SOURCE

in frequency control—components and systems

Today, an increasing number of electronic systems demand a degree of reliability heretofore unobtainable. That is why more and more manufacturers are specifying Bulova.

Bulova crystals, filters, ovens, packaged oscillators, and Bulova frequency control systems, custom-designed for either limited or mass production, meet and exceed military and industrial specifications.

Bulova's experience in mastering many of the most difficult problems involving component and system reliability has made it the *number one source* for frequency control devices. This experience can prove of immense value in your particular program. For more information write Dept. A-1183, today.

BULOVA WATCH COMPANY

ELECTRONICS DIVISION • WOODSIDE 77, NEW YORK

Write in No. 320 on Reader Service Card at start of Product Review Section

SPACE/AERONAUTICS

**Air Force
"Sunday
Punch"**

ATLAS



Boosted into space by the fiery thrust of three huge rocket engines, the seven-story Atlas intercontinental ballistic missile roars upward from its Cape Canaveral launching pad. Quickly it sheds the frost encrusting the liquid oxygen tank and races to its predetermined destination in the far reaches of the globe. In its size and range and capability, the Air Force Atlas is a

commentary, for all the world to heed, of the necessity to maintain the peace. RCA's Missile and Surface Radar Department has been privileged to design and develop ground check-out, launch control and cabling equipment as a major subcontractor to Convair (Astronautics) Division of General Dynamics Corporation, the Atlas prime weapons systems contractor.

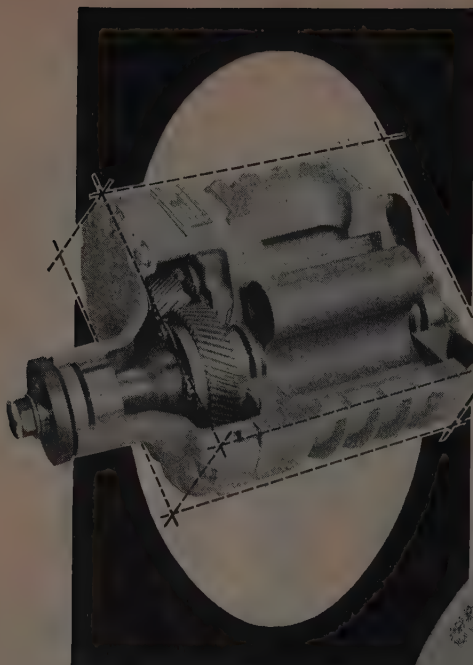


Tmk(s) ®

RADIO CORPORATION of AMERICA.

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, N. J.

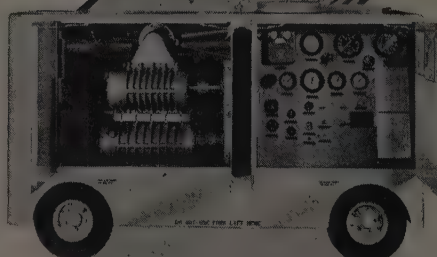


**delivers
1,000 cfm
(up to 14 psig)**

**takes
less than
5½ cu. ft.**

**Arnolt Corp. Model CPT6-O
TESTER, PRESSURE CABIN
LEAKAGE (For Military
and Civilian Aircraft)**

Utilizes 2-stage M-D Blower Unit
1000 SCFM—10 PSIG
800 SCFM—12.5 PSIG
600 SCFM—14.0 PSIG

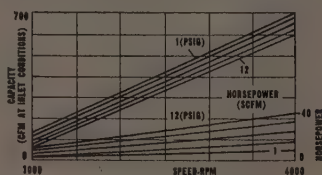


**ARNOLT CORPORATION FINDS M-D ROTARY
POSITIVE BLOWERS USE LESS H.P.—
EFFICIENT AT WIDE SPEED RANGE**

The Arnolt Corporation incorporates a 2-stage M-D Blower Unit in their CPT6-O cabin pressure leakage tester for several reasons. First, it delivers adequate CFM of air at the PSI required to do the testing job with ease, plus an average 50% reserve capacity; Second, the M-D 3-lobe rotary positive blower takes up less cubic space than any other unit of comparable performance; Third, it operates as effi-

ciently at any speed or pressure; And finally, it can be operated with a smaller driver of less size and weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. The capacity of the Model 4012 (4" rotor 12" long) is shown below. Capacities of 11 other production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.



For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN
A Subsidiary of Miehle-Goss-Dexter, Inc.



Write in No. 256 on Reader Service Card at start of Product Review Section

PRODUCT REVIEW

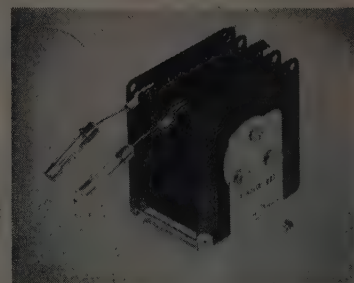
MAGNETRON TEST KIT is portable

Capable of testing both X- and C-band 100- and 400-watt magnetrons, the beacon magnetron test kit is portable and can be used in the field as well as on production lines, says Bomac Laboratories, Inc., Dept. S/A, 1 Salem Road, Beverly, Mass.

The unit measures 22x15x19 in. and is available with or without a power meter and spectrum analyzer.

Write in No. 314 on Reader-Service Card

SILICON RECTIFIERS offer self-protection



Protection of rectifier units against short circuits, surge currents, and sustained overloads through the use of low-cost standard fuses is now possible by a diffused production technique, according to Trans-Sil Corp., Dept. S/A, 55 Honeck St., Englewood, N.J.

The rectifier stacks are available in half-or-full-wave assemblies from 110 to several thousand amperes, with peak inverse rating of 50-volt multiples to thousands of volts. The hermetically sealed units offer reliable operation without derating from -65 C to +150 C.

Write in No. 315 on Reader-Service Card

STEPPING SWITCH for high speeds

This high speed "Miniature Uniselect" was primarily designed for use in automatic switching and timing-control circuits. The Uniselect will operate at speeds up to 80 steps per second on impulse drive (80% make, 20% break) from biases of 24, 50, or 110 volts dc, says Imtra Corp., Dept. S/A, 11 University Road, Cambridge 38, Mass.

Up to 12 banks can be fitted, each having 30 individual contacts mounted in a complete circle. When only seven banks or fewer are used, a sequence switch can be fitted. The sequence switch-wiper steps once for each complete revolution of the main wiper assembly. All wipers can be either bridging or non-bridging. The bank can be swung open on its bridges, permitting ready access for maintenance or adjustment.

Write in No. 316 on Reader-Service Card

more on page 222

Write in No. 257 on Reader-Service Card
SPACE/AERONAUTICS

LINDE'S NEW PLASMARC TORCH SERVICE

Brings Industry Production Parts From Refractory Metals

No other method of fabricating refractory metals can match this. . . . The high melting points of tungsten, tantalum, and molybdenum are no longer a problem. For LINDE's new PLASMARC Torch, working in the temperature range between 15,000 and 30,000 degrees K., can coat parts or form shapes of virtually any size or complexity. It's an entirely new way to make such articles as rocket nozzles, crucibles, components for electronic and X-ray use, and parts for atomic energy equipment!

The quality of these pieces is uniformly high. Tolerances can be held to $\pm .002$ in. or better. The metal

loses none of its purity and superior density is achieved.

With the PLASMARC Torch, LINDE is equipped to supply you with parts made of, or coated with, refractory metals; or made of a variety of metals combined with non-metals or reinforced plastics. LINDE will also provide a wind-tunnel materials testing service based on this device. For information on this extension of LINDE's well-known Flame-Plating service, write Dept. AW-13, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.




ROCKET NOZZLE



ELECTRONIC GRID CAGE



TUNGSTEN-COATED GRAPHITE NOZZLE



CRUCIBLE

The PLASMARC Torch employs a non-transferred electric arc to generate such high temperatures that powder or wire fed into the chamber is literally melted. Inert gases flow and continuously carry the metal particles in a plastic state and deposit them on the workpiece at near-sonic speeds. Jets of CO₂ cool the particles instantly to form heat- and erosion-resistant material. Coatings—even on graphite—have an excellent bond. Shapes are built up on machined mandrels, which are then etched away to leave parts such as those shown above.

Linde

UNION
CARBIDE

"Linde", "Union Carbide" and "Plasmarc" are trade marks of Union Carbide Corporation.

MAN'S FIRST SPACE COMMUNICATION STATION



On 12 October 1958, an historic event took place. A group of Space Technology Laboratories engineers at Cape Canaveral, Florida, transmitted radio signals far out into space to the NASA/Air Force Pioneer space probe vehicle. The tiny receiver and transmitter in the Pioneer relayed these same signals to the Space Technology Laboratories' group at Manchester University, England. • This significant experiment promises, like those earlier achievements of Morse, Bell, and Marconi, to pave the way for the use of space vehicles to relay information to and from points on earth. One day the entire world will view televised events as they happen. • Future experiments of this kind will undoubtedly assist mankind in his search to understand, use, and benefit from his knowledge of space phenomena. • Scientists and engineers whose interests and abilities enable them to contribute to these developments are invited to join our technical staff.

Space Technology Laboratories, Inc. P.O. BOX 95001, LOS ANGELES 45, CALIFORNIA



The 250' radio telescope pictured here is operated by a team of British scientists under the direction of Professor A. C. B. Lovell, University of Manchester, whose cooperation contributed materially to making this achievement possible.



MAGNESIUM



THERMAL PROPERTIES OF LIGHTWEIGHT MAGNESIUM

offer advantages to
missile men

Most engineers are aware of the advantages available to them when they combine magnesium's light weight with its good mechanical properties at elevated temperatures up to 800°F. There are, however, other advantages such as thermal properties that are less well known. They, too, can be of real value to missile designers. In many cases they will open new areas in design previously considered closed to magnesium.

Let's consider one of these, magnesium's high specific heat and its relationship to missiles. This can mean lower temperatures for given flight conditions. As a result magnesium can be used under very severe flight conditions for short time applications. (See Fig. 2.) This permits the use of magnesium in high speed missiles which are exposed to heat generating atmosphere for only a matter of a few

seconds. With magnesium acting as a heat sink it can result in reducing environmental temperature for electronic instruments.

Magnesium offers other thermal properties that are of value in aircraft and missile design. For example, the thermal diffusivity of magnesium-thorium alloys $\left\{ \frac{\text{Thermal conductivity}}{\text{Specific heat} \times \text{density}} \right\}$ is high and remains fairly constant over a large temperature spread. Between 68° and 900°F. the thermal diffusivity of these alloys is in the range of 0.57 and 0.75 cm.²/sec. (2.2 and 2.9 ft.²/hr.)

For more complete data send for Bulletin 141-187 "Magnesium Alloys for Elevated Temperature Use." Contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department 1300EW2.

Design a missile with light, strong magnesium alloys

1. SHEET for internal or external skins of body.
2. DEEP DRAWN HOUSINGS AND CASTINGS for guidance and other instrumentation.
3. CASTINGS AND EXTRUSIONS for body frame.
4. CASTINGS AND EXTRUSIONS for fin and wing construction.
5. ROUND EXTRUDED TUBING for integral body sections.
6. SHEET for external skins of fins, rudders and wings.

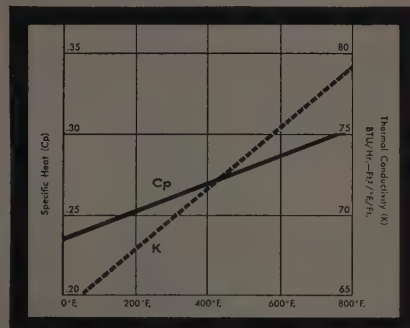


Fig. 1. Specific Heat and Thermal Conductivity of Magnesium-Thorium alloys.

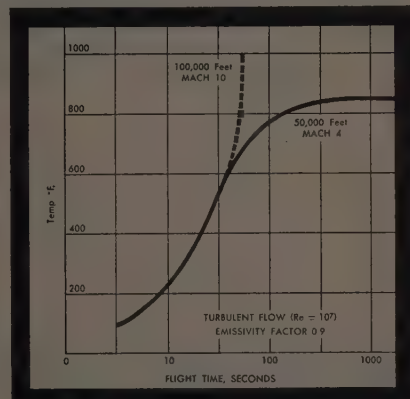


Fig. 2. Effect of Structure Temperature and Flight Time on Mg-Th Sheet Alloys at Mach 4 and 50,000 Feet and Mach 10 and 100,000 Feet.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

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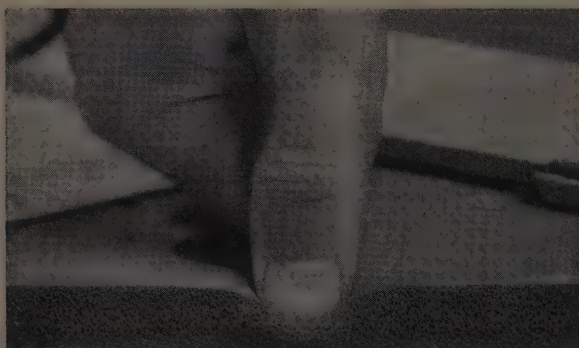
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INFINITE POSITIONING CONTROLS
positive, no friction settings



available in 54 combinations
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Silicone Sponge Rubber

for sealing, gasketing, pressure pads,
vibration dampening —100°F to 480°F

Low density COHRLastic R-10470 silicone rubber is completely flexible after 72 hrs. at 480°F, shows no brittleness after 5 hrs. at -100°F. High tensile, tear and elongation. Closed cell construction is non-absorbing. Called out on aircraft and electronic drawings and specifications. Available from stock in sheets 1/4" thru 1/2", in rod .180" thru .585" Special extruded shapes made to order.

FREE SAMPLES and folder—write, phone or use inquiry service.

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AIRFRAME
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SHEET & SPONGE



MOLDINGS
& EXTRUSIONS

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PRODUCT REVIEW

FORMING MACHINE has high production rate

A new, large size vacuum forming machine, the Master-Vac features a 21-sq ft forming area, with roll fed and semi-automatic take-off, for single-operator, high speed, continuous production of thin gauge (five to 15 mil range) plastic articles. Roll up to 44 in. wide are handled with ease at feed rates of 540 ft/hr. It may also be used with heavy gauge sheet plastic up to 0.125 in. thick, says Auto-Vac Co., Dept. S/A, 1983 State St. Ext., Bridgeport, Conn.

Other features include automatic tension controls, remote controls, and a three-clok system for high speed forming cycles. Sales price is near \$12,000.

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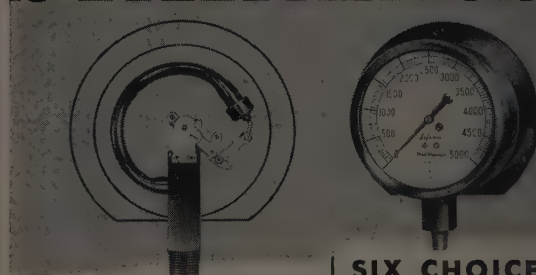
POTENTIOMETERS encased in aluminum

Lightweight potentiometers with power ratings of 1.5, 2.5, 3.5 and five W have been designed for a life expectancy of two million revolutions according to Osborne Electronic Corp., Dept. S/A, 712 S. E. Hawthorne Blvd., Portland, Ore. The units, which have aluminum cases and covers, operate over an ambient temperature range of -55 to +125 deg C.

Servo-mount types have ball bearings and bushing-type mounts, sleeve bearings. Any reasonable number of sections may be supplied ganged together to desired resistance and phasing. Number and location of taps vary according to model.

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more on next page

STAINLESS!



—from inlet to tip

Now the superlative Master-gauge is available in a wider range of corrosion resistant tubes and sockets than any other pressure gauge.

Check the adjoining list. And remember that tube socket and tip are fused into one piece by the exclusive Marsh "Conoweld" process.

Marsh alone combines the "Conoweld" construction, the copper-clad "Marshallloy" case, the finer Mastergauge movement, the Marsh "Recalibrator", the new "Safecase." Ask for data covering your specific needs.

SIX CHOICES of tubes and sockets

4130 alloy steel tube with alloy steel tip and socket.

403 stainless steel tube with alloy steel tip and socket.

403 stainless steel tube with 416 stainless tip and socket.

316 stainless steel tube with alloy steel tip and socket.

316 stainless steel tube with 303 stainless tip and socket.

"K" Monel tube with alloy steel tip and socket.

MARSH INSTRUMENT CO., Sales affiliate of Jas. P. Marsh Corp. Dept. 43, Skokie, Ill.
Marsh Instrument & Valve Co., (Can.) Ltd. • 8407 103rd St., Edmonton, Alberta, Can.

MARSH



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SPACE/AERONAUTICS

A UNIQUE SUR-
FACE AND BALANCE
TRANSPARENCY ARE
BOTH OBTAINED IN
K&E HERCULENE

FOR PENCIL

... INK

... AND TYPING

Excellent "take"...
complete erasability
for all three

A unique surface
balance and transparency
are both obtained in
K&E Hercules Drafting
Film. It is the tough-
est, most durable draft-
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Now K&E provides the ultimate "3-way" surface for super-tough HERCULENE™ Drafting Film

Only K&E Herculene Drafting Film has a surface perfectly engineered for pencil, ink and typing... plus the extreme toughness and durability of a DuPont "Mylar®" film base. You get the absolute assurance of superior "take". And Herculene erases easily and quickly without the need for erasing or correcting fluids.

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so tough you can hardly tear it. It can't be damaged by moisture. And it's permanent... your drawings are resistant to damage by aging or handling.

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you can make prints from a Herculene Drawing indefinitely without its yellowing or tearing, cracking or becoming brittle.

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KEUFFEL & ESSER CO., Dept. AA-2, Hoboken, N.J.

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Name & Title: _____

Company & Address: _____

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TUBE DISTRIBUTORS BALANCED SERVICE

delivers steel tubing at no "premium price"!

Fact!... You cut production costs, warehousing and handling costs, minimize your steel tubing investment, and *pay no premium*, when you buy in warehouse quantities.

How?...By making full use of TD's "balanced service":

1. Technical assistance from steel tubing specialists*.

2. Thousands of sizes in all standard types and analyses in stock.

3. Systematic handling that insures on-time delivery.

4. Personalized Inventory Plan custom-tailored to your requirements.

5. TD's *complete* quality control program.

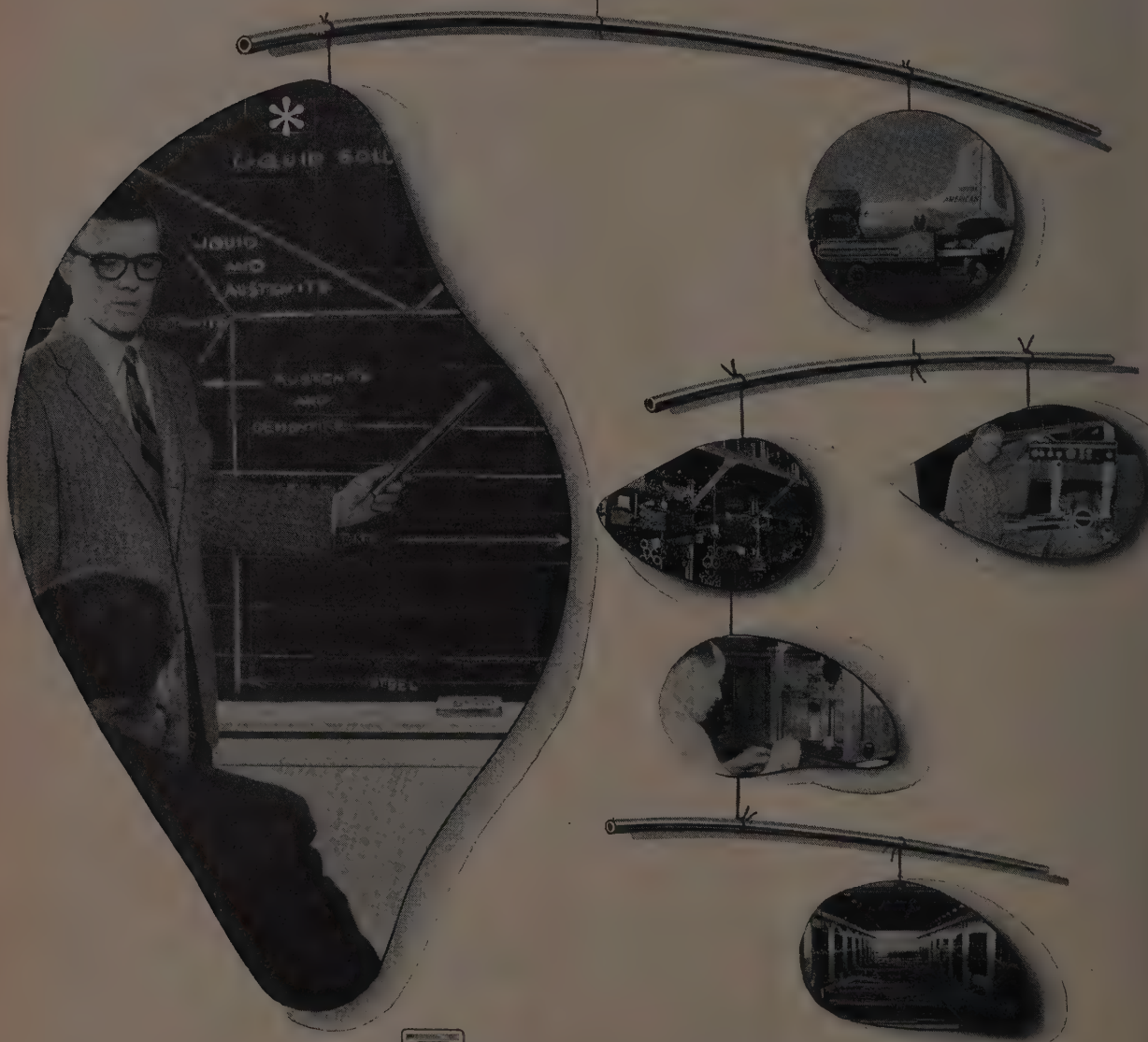
6. Extra warehouse service.

*TECHNICAL ASSISTANCE FROM STEEL TUBING SPECIALISTS!

TD's technical and sales staff are all thoroughly trained men who take part in weekly training sessions which provide them with up-to-the minute knowledge of what's available, how it can be bought most economically, and how it can be fabricated. Put TD's technical assistance to work for you!

Call TD for—stainless, alloy and carbon steel tubing, both aircraft and commercial quality.

Write Dept. A-23 today for your copy of "Eighteen Ways to Save Money in Your Steel Tubing Purchasing," and the name of your nearest TD representative.



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GARDEN CITY
NEW YORK

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SPACE/AERONAUTICS

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UAP FUEL HEATERS

PREVENT FUEL SYSTEM ICING!

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Freezing water in fuel systems is recognized as being a general trouble maker in aircraft operation. The need for a positive method of preventing fuel icing has led to the incorporation of fuel heaters as both original and retro fit installations on military and commercial aircraft.

A solution to the problem was achieved by United Aircraft Products, Inc. with the development and production of two distinct types of fuel heaters, *Lube Oil Fuel Heater*, *Compressor Bleed Air Fuel Heater*. Heat to apply to engine fuel is taken from either of two sources—engine compressor bleed air or engine lubricating oil. The type of engine determines which type of fuel heater will be used.

UAP is in production now with several types of highly reliable models of both types in every day service. For specific information covering UAP produced fuel heaters, their operational temperatures, types of control valves, pressure drops, weights and sizes please call the UAP Contractual Engineering Office nearest you.

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NEW YORK.....50 E. 42nd St., New York 17, N. Y., MU 7-1283
OHIO.....1116 Bolander Ave., Dayton, Ohio, BA 4-3841
CANADA.....United Aircraft Products, Ltd., 5257 Queen Mary Road,
Montreal, Canada, ELwood 4131

Compressor bleed
air fuel heater
and control valve

Lube oil fuel heater with
fuel filter and control valve

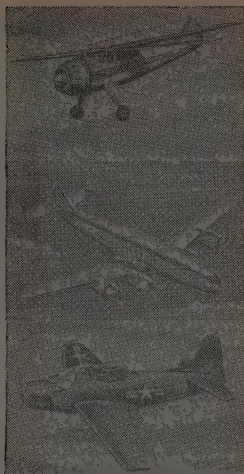
a famous family of aircraft essentials since 1929

UNITED AIRCRAFT PRODUCTS, INC.

1116 BOLANDER AVENUE, DAYTON, OHIO



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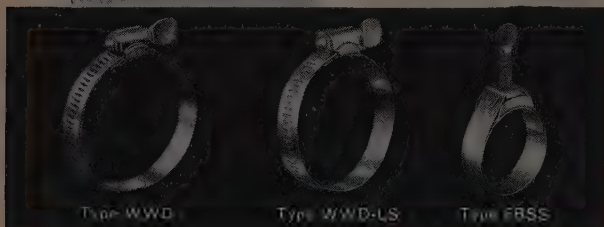
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Specifications

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for over a Quarter of a Century



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**\$1064 to Overhaul Aircraft Generator at Factory
\$60 to Rhodium Plate Commutator and Slip Rings**

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Dalic plating makes the difference. Using a specially developed rhodium plating solution and Dalic selective plating equipment, useful operational time of the main generator of a bomber has been increased to some 350 hours. Formerly, time between mandatory overhauls was only about 70 hours.



SAVINGS: Two or three overhauls, at \$1,064 each, plus cost of time and labor to remove and reinstall generator.

If you're concerned with military or civil aircraft, missile controls, servos, high-quality electrical equipment, investigate rhodium plating with Dalic equipment. It offers the following advantages:

Longer commutator life • Reduced contact resistance • Higher starting and running torques • Elimination of static and noise in radio and other electronic equipment • Reduces temperature by as much as 80° C • Increased power/current ratio

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Cuyahoga Falls, Ohio
D & S AVIATION CO., LTD.
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Pont Viau, Quebec

DALIC METACHEMICAL LTD.

121 Judge Road, Toronto, Ontario

Write in No. 170 on Reader-Service Card

PRODUCT REVIEW

E-RINGS have more gripping power

This Walds Truarc Series 5144 reinforced E-ring fastener is designed for use in assemblies in which the ring is subject to strong push-out forces resulting from heavy vibration and shock loads, high rotational speeds or relative rotation between the retained parts. It has about five times the gripping power of conventional E-type rings and 50 per cent higher rpm limits, and may be used with abutting retained parts having large corner radii or chamfers, says Waldes Kohinoor, Inc., Dept. S/A, 47-16 Austel Pl., Long Island City 1, N. Y.

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POTENTIOMETER is noise-free

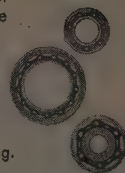
The Model-157, a self-aligning, linear-motion potentiometer useful for missile applications, is capable of noise-free operation at 40 g's, from ten to 2000 cps, says Bourns Laboratories, Inc., Dept. S/A, P. O. Box 2112, Riverside, Calif. The error up to 2000 cps is under ½ per cent, and there is no mechanical backlash.

Electrical noise of the Align-O-Pot during vibration is not more than 0.1 per cent of the total variable resistance, or 100 ohms, whichever is greater. The device has a floating shaft to allow free lateral movement of an actuator without side-load effect. Standard travels are 0.50, 1.00 and 1.37 in., and body lengths range from 1.25 to 2.125 in., depending on travel. The Model 157 is available with single or dual potentiometer outputs, in resistance values of one, two five, ten and 20 K.

Write in No. 204 on Reader-Service Card
more on page 228

Split- Second Starters with Super Finishes

Advanced retainer design and rigid manufacturing control for MPB bearings eliminate torque pulses due to hang-up; micro-finished balls and raceways assure low torque with minimum variations and maximum reliability. Write MPB Inc., 1402 Precision Park, Keene, N. H., for catalog.



MPB helps you perform miracles in miniaturization

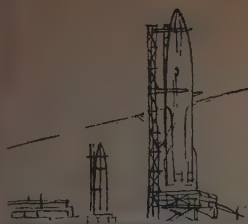
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SPACE/AERONAUTICS

For Positive Reliable Control and Protection use



KLIXON

Circuit Breakers,
Precision Thermostats, Switches and Motor
Protectors in Aircraft and Guided Missiles



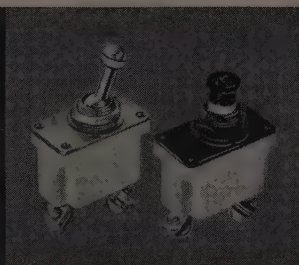
KLIXON D6760 CIRCUIT BREAKER

Thermal-type, three phase. Interrupts high AC short circuits . . . trips quickly . . . provides simultaneous tripping of all three phases should any one phase become overloaded. Ratings 5 to 60 amperes; weight 227 grams; minimum AC rupture capacity 2500 amperes, 1 ϕ , 120 VAC, 400 cps.



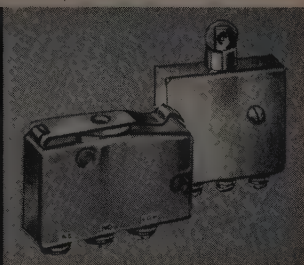
KLIXON D6752-5 CIRCUIT BREAKER

High temperature, push-pull, indicating type especially designed to compensate for ambient temperature in a -60°F to +250°F range. Carries rated current at 250°F and 115% of rating at -60°F and +77°F. High AC and DC rupture capacity, long cycling life (10,000 cycles min.), fast sensing and tripping. Ratings 5 to 50 amperes; weight 2.5 ozs.



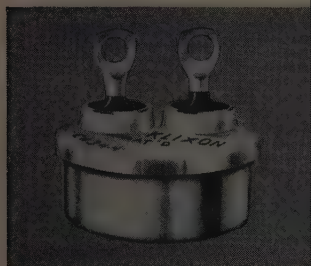
KLIXON D7270-D7271 CIRCUIT BREAKERS

Two miniature breakers different only in actuators. Simple trip-free design about 1/4 the size of MS25005 and MS25017. Only three moving parts — actuator, slide and thermal disc. Ratings 3 to 35 amperes; weight 1.5 ozs.; high rupture capacity 3500 amperes, 120 VAC, 400 cps.; 4,000 amperes, 30 VDC.



KLIXON KX4 and KX5 SERIES PRECISION SWITCHES

Hermetically sealed snap-action limit switches. One piece Sine Blade. Steel case withstands high impact and compression loads. Both series available with auxiliary leaf, roller or push-button actuators. Ratings 10 amperes, 115 VAC or 30 VDC resistive. Ambient temperatures -65°F to +375°F; weight 1 oz.



KLIXON M1 PRECISION THERMOSTAT

Hermetically sealed, vibration resistant, snap-action. Conforms with MIL-E-5272 and MIL-T-5574A. Pre-set and non-adjustable. Temperature settings from -65°F to +400°F. High dielectric strength 1250 VAC. Ratings up to 7 amperes, 30 VAC/DC resistive; or 6 amperes, 125 VAC; or 3 amperes, 250 VAC. Weight 5 grams.



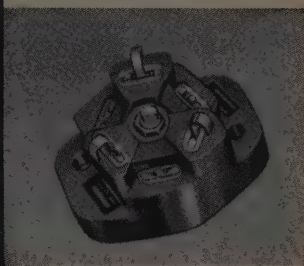
KLIXON C4391 PRECISION THERMOSTAT

Hermetically sealed, fixed temperature, snap-action, automatic or manual reset. With or without overmold. Temperature settings from -10°F to +400°F with switch-action SPST or SPDT. Ratings up to 10 amperes, 30 VDC; or 15 amperes, 120 VAC. Weight (no overmold) 3/4 oz.; with overmold and 12" leads, approximately 2 oz. Variety of mounting brackets.



KLIXON SINGLE-PHASE MOTOR PROTECTORS

Used whenever maximum motor output and safety are required including protection for actuators, blowers, pump motors, flap and landing gear motors. These types are for single-phase motors with maximum continuous operating temperatures up to 225°C. Maximum rupture capacity is 1200 amperes, 28 VDC. Available in automatic and non-automatic reset types.



KLIXON THREE-PHASE MOTOR PROTECTORS

Designed to match the thermal characteristics of electric motors, they prevent motors from reaching destructive temperatures without limiting motor output. For 3-phase motors with maximum continuous operating temperatures up to 225°C. Maximum rupture capacity is 400 amperes, 200V, 400 cycles. Available in open and hermetically sealed construction in automatic and nonautomatic reset types.

General Plate Products for Aircraft and Guided Missiles

NEW ENGINEERING METALS: Zirconium, zircaloy II and III, hafnium, beryllium, vanadium, columbium (niobium), tantalum, molybdenum, titanium, tinamel, high temperature alloys — supplied or re-rolled as low as .0005" thick depending on the material.

STAINLESS STEEL CLAD COPPER STRIP: Stainless surface provides resistance to corrosion, the copper — high thermal conductivity at elevated temperatures. Can be blanked, drawn, spun, formed, brazed, and spot or seam welded.

THIN GAUGE METALS: Haynes Stellite Alloys, special stainless steels, and super alloys supplied or toll-rolled.

ALFENOL (16% Aluminum — Balance Iron Alloy): Assures constant magnetic properties in electro-mechanical mechanisms.

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KLIXON Circuit Breakers, Precision Switches, Precision Thermostats and Motor Protectors are small in size and light in weight; they respond quickly and with accurate repeat performance; they have ample capacity to handle a wide range of electrical loads; their calibrations stand up in the face of severe environmental conditions.

Competent Spencer Engineers at the factory and in the field will gladly make test applications of the KLIXON Line. Write for "KLIXON Controls for Aircraft and Guided Missiles" Catalog.

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FOR EVERY INDUSTRY

EXTRA HIGH PRESSURE FINE METERING



HIGH PRESSURE NEEDLE VALVE

10,000 psi hydraulic service. Forged stainless steel one-piece body. Panel mounting. Good flow characteristics, fine metering, easy to turn. Water, gas, oil and vacuum service, $\frac{1}{8}$ " to $\frac{1}{2}$ " pipe or straight thread tube connections.

MICROMETER ADJUSTMENT NEEDLE VALVE

Best for extra fine metering. Micrometer adjustment, precision taper stem. 5000 psi service -65° to 350° F., oil, water, etc. Brass, aluminum alloy, steel, or stainless steel body. $\frac{1}{8}$ " and $\frac{1}{4}$ " sizes. Premolded or O-ring packing. Panel mounting.



5000 psi THROTTLE-FLO VALVE

Accurate throttling up to 5000 psi. Finger tip control. Pilot operation of large dynamically balanced piston. Full flow, yet accurate to 1/100 gpm through entire range. Positive seal. Low pressure drop. Aluminum alloy, $\frac{1}{2}$ ", $\frac{3}{4}$ ", 1" internal straight thread connections. Hydraulic seals — others available.

HYDRAULIC BLEEDERS

Primarily used for bleeding air from hydraulic systems, for working pressures to 3000 psi at temperatures from -65° to 180° F.



Fluid control valves of many types have been developed and are manufactured by REPUBLIC. A wide line of quality standard valves includes needle, globe, check, plug, selector and relief valves, as well as other units for industrial, chemical, aircraft, missile and ground handling equipment.

Specialists in valving and manifold design to meet your specific application. Write for catalog.

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GLOBE NEEDLE



PLUG



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INTERFERENCE BLANKER for radar

This new radar interference blander, Model RB-128, eliminates main bang interference in a group of normal and MTI radar sets or reduces it to a negligible value. In operation, the interfering signal is bracketed with a negative blanking gate to eliminate it from the protected radar's display. Since the PRR of the protected radar and that of the interfering radar are usually not synchronized, any loss of displayed information is unimportant, says Empire Devices, Products Corp., Dept. S/A, Amsterdam, N.Y.

The system is designed to protect two normal video channels and one MTI video channel. A guard-band receiver samples all signals at the output of the offended radar's crystal mixer, distinguishing between interfering signals and the offended radar's own signals.

Write in No. 205 on Reader-Service Card

SERVO AMPLIFIER for missile use

The A8104 servo amplifier is a transistorized unit designed to deliver control phase power to 400-cycle servo components needing up to 16 W of input power, says Kearfott Co., Inc., Dept. S/A, 1500 Main Ave., Clifton, N.J. The plug-in unit, suited to missile and high-speed aircraft use, is completely potted for protection against extreme shock.

Voltage gain is adjustable between 100 and 200 for a 40-V load, and between 300 and 6000 for a 115-V load. Dimensions of the amplifier are $2\frac{1}{2}$ x $2\frac{3}{8}$ x $2\frac{1}{4}$ in., and the unit may be mounted in any position.

Write in No. 206 on Reader-Service Card

POTENTIOMETER measures temperature

Excellent accuracy in missile ground and flight-test temperature measurements may be expected from this versatile servo-driven, self-balancing potentiometer, says Avion, Inc., Dept. S/A, 58-15 Northern Blvd., Woodside 77, N.Y. The system automatically and continuously compares thermocouple emf with that of a highly stable reference voltage, and it accommodates any range of temperature measurements, including those in the cryogenic region.

Accuracy is said to be better than ± 0.3 per cent of scale span and sensitivity is ± 0.1 per cent of span. The system can be supplied with auxiliary outputs for telemetering, recording, remote monitoring and control of other equipment. All components except the probes are housed within one unit which, for typical applications, measures $2 \times 5\frac{1}{2}$ in. and weighs under one lb.

Write in No. 207 on Reader-Service Card

IRON-BASED ALLOY has high strength rating

J-1300, a precipitation hardening iron-based alloy has one of the highest strength/weight ratios of any iron-based alloy in the 1300 deg F range, according to Metallurgical Products Dept. General Electric Co., Dept. S/A, 11177 Eight Mile Rd., Detroit, Mich. It is particularly useful for jet turbine wheel, rings, shafts, and compressor wheels and blades.

In addition, its high residual strength after long exposure to stress and high temperatures and its ease of fabrication make it an ideal bolt and fastener material. Minimum tensile strength at 1200 deg F is 135,000 psi, and rupture strength at 1300 deg F is said to compare with or exceed that of other iron-based alloys at 1200 deg F. The alloy is available in forgings and bar stocks.

Write in No. 321 on Reader-Service Card

more on page 232

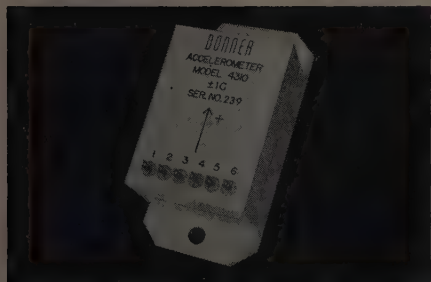
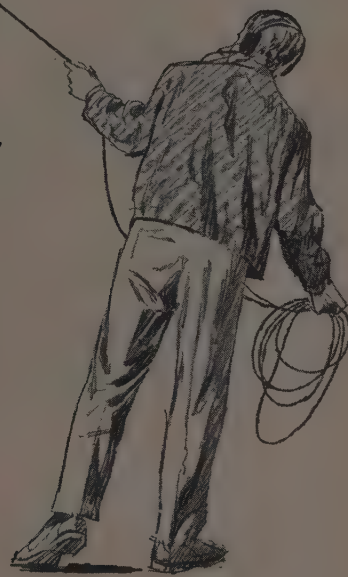


DONNER

lets you lead a Sikorsky with one hand!

Using only a few ounces of force, anybody can walk a helicopter fitted with automatic stabilization equipment using a Donner designed stabilizing coupler.

In a more useful vein, the big birds perform vital tasks where the ability to hover precisely and maintain stability is critical. Currently, Donner equipped Sikorskys are used extensively for submarine detection, surveillance, rescue, lifting, and a host of other activities.



Transistorized Model 4310
0.1% linear accelerometer shown 1/2 size.

Complete information is contained in Data File 410. Send for your copy without obligation — use the convenient coupon.

Heart of the Donner coupler is a small Donner servo accelerometer which measures linear acceleration to at least 0.1% of full scale. The internal servo system offers excellent resolution and linearity. These sturdy reliable instruments are hermetically sealed and magnetically shielded. The entire Donner system weighs less than 25 pounds.

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Please send Data File 410 on your linear servo accelerometers.

Name

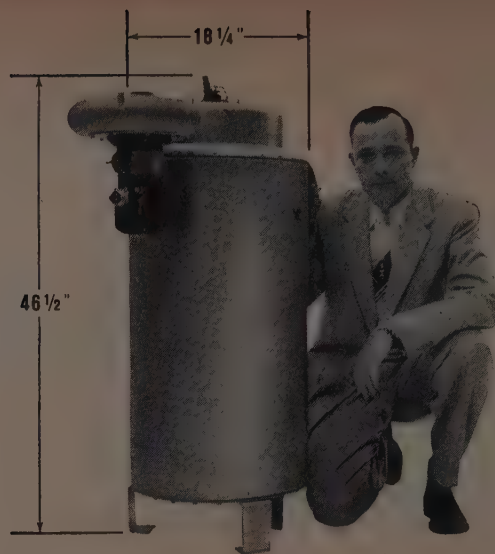
Title

Company

Street

City and State

Write in No. 174 on Reader Service Card at start of Product Review Section



million btu/hr!

For missile ground support applications this compact new Janitrol liquid heater delivers heat up to a rate of 1 million Btu/hr. A complete variable output heating system, it automatically maintains liquid at any desired temperature . . . reliably.

This 257 pound package is ideally suited to such applications as heating missile fuel during storage and transfer, vaporizing liquids, and in a wide variety of support vehicles and buildings. For both material and personnel comfort heating the new Janitrol liquid heater is a simple, trouble-free way to get large quantities of controlled heat.

Heater burns either diesel fuel, gasoline, or JP-4, and can be converted with a simple adjustment. Radio noise shielding meets military specifications. It will operate in extreme environments to -65°F .

Janitrol's new liquid heaters may be used individually, or in multiples to meet virtually any heat requirement.

Wherever heat is needed in missile support equipment Janitrol may already have what you need. Contact your Janitrol representative now for the full story on liquid heaters. Janitrol Aircraft Division, Surface Combustion Corporation, Columbus 16, Ohio.

1. fuel transfer



2. support vehicles

3. comfort heating



pneumatic controls • duct couplings & supports • heat exchangers
combustion equipment for aircraft, missiles, ground support

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SPACE/AERONAUTICS



HERE THEY ARE!

The SMALLEST—and the FASTEST—high pressure pneumatic solenoid valves ever made!

On the left above, the world's smallest 3000 psi pneumatic solenoid valve. (Overall height $3\frac{3}{8}$ " , total weight 3.04 oz.) Beside it, the world's fastest 3000 psi pneumatic solenoid valve, with a response time of 0.018 seconds! Developed by Walter Kidde & Company, and now available on an off-the-shelf basis, these two valves were developed primarily for missile applications, but a glance at their specifications and performance data suggests uses in both today's—and tomorrow's—high-speed *manned* aircraft.

For more information on these new tested and proven valves, as well as more than 100 qualified pneumatic system components, write to Walter Kidde & Company—pioneers in aircraft pneumatic systems, and *still* first with the finest in pneumatic components!

KIDDE VALVE #872071 (The tiny one)
 Operating Pressure 0-3000 psi
 Temperature Range -75°F. to $+350^{\circ}\text{F.}$
 Leakage 3 cc/hr.
 Flow Equivalent to .05 orifice.
 Operating Current .5 to 1.5 amps.
 Operating Voltage 14-30 V.D.C.
 Mounting by tubing support
 Life 100 to 10,000 cycles, depending on operating conditions.
 Weight .19 lbs.

KIDDE VALVE #872458 (The speed demon)
 Operating Fluid Dry air/nitrogen gas
 Operating Pressure Range 80 to 3250 psi
 Proof Pressure 4875 psi
 Burst Pressure 8125 psi minimum
 Ambient Temperature Range -65°F. to $+160^{\circ}\text{F.}$
 Flow Factor 1.37
 Voltage Range 18 to 30 V.D.C.
 Current (28 V. @ 80°F.) 1.2 amps.
 Coil Resistance (80°F.) 21.5 to 24 ohms
 Weight 1.40 lbs
 Response Time 0.018 seconds



District Sales Engineering Offices:
 Dallas, Tex.—Dayton, Ohio—St. Louis, Mo.
 San Diego, Calif.—Seattle, Wash.—Van Nuys, Calif.—Washington, D. C.

Walter Kidde-Pacific, Van Nuys, California
 Walter Kidde & Company of Canada Ltd.
 Montreal—Toronto—Vancouver

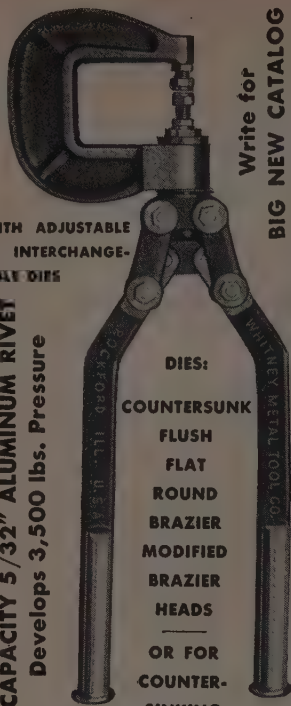
Walter Kidde & Company, Inc., Aviation Division, 214 Main Street, Belleville 9, N.J.

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"REDI-SET" RIVET SQUEEZERS

WITH ADJUSTABLE
& INTERCHANGE-
ABLE DIES

CAPACITY 5/32" ALUMINUM RIVET
Develops 3,500 lbs. Pressure



DIES:

COUNTERSUNK

FLUSH

FLAT

ROUND

BRAZIER

MODIFIED

BRAZIER

HEADS

OR FOR

COUNTER-

SINKING

Write for
BIG NEW CATALOG

WHITNEY METAL TOOL CO.

710 Forbes St., Rockford, Ill. Since 1910

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PRODUCT REVIEW

X-RAY DETECTOR is transistorized

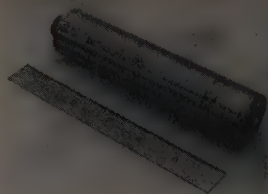


A warning against over-exposure to X-rays from high-power radar equipment and other high-voltage apparatus is provided by an eight-lb transistorized unit, the Model 607-X, says Universal Transistor Products Corp., Dept. S/A, 17 Brooklyn Ave., Westbury, L.I., N.Y. The device operates on flash-light batteries.

It operates accurately over the 100 to 600-kev energy level. Internal shielding permits accuracy despite high-intensity r-f pulses or other electromagnetic, magnetic and electrical fields.

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PREAMPLIFIER for high impedance sources



Two new transistor preamplifiers, Models 110 and 120, have been designed for impedance transformation and 20 db of gain. They were developed for use with high impedance sources, such as accelerometers and hydrophones, says Chesapeake Instrument Corp., Dept. S/A, Shadyside, Md.

Input impedance of the 110 is one megohm, and that of the 120 is five megohms. Output impedance of both is 600 ohms. For the 110, frequency response is 100 cps to 80 kc, and equivalent input noise is ten uv. Response of the 120 is ten cps to 150 kc, and input noise is 50 kv. The devices can be powered from internal mercury battery or external sources.

Write in No. 209 on Reader-Service Card
more on page 236

DO YOU NEED AUTOMATION

for
FINISHED WIRE LEADS
with
Terminals Attached?

NEW ARTOS TA-20-S

Performs 4 Operations Automatically!

1. Measures and cuts solid or stranded wire 2" to 250" in length.
2. Strips one or both ends of wire from 1/8" to 1".
3. Attaches any prefabricated terminal in strip form to one end of wire. (Model CS-9-AT attaches terminals to BOTH ENDS OF WIRE simultaneously.)
4. Marks finished wire leads with code numbers and letters (optional attachment).

UP TO 3,000

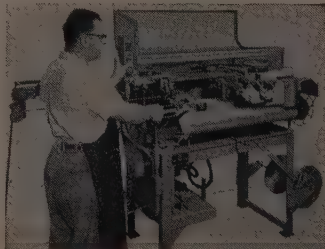
finished pieces per hour. Can be operated by unskilled labor. Easily set up and adjusted to different lengths of wire and stripping. ENGINEERING consultation without obligation. Machines for all types of wire lead finishing.

AGENTS
THROUGHOUT THE
WORLD

ARTOS ENGINEERING CO.

2773 South 28th Street • Milwaukee 46, Wisconsin

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WRITE for FREE Bulletin No. 655 on Artos TA-20-S

"Best Suited" for HIGH TEMPERATURES

VARGLAS SILICONE CLASS H TUBING and SLEEVING

for applications requiring prolonged heat endurance at temperatures up to 260°C.

Varglas Silicone tubing and sleeving were developed by Varflex for applications involving continuous operating temperatures up to 260°C. Exceptional stability is combined with the following qualities . . .

Flexibility—Sharp turns and 90° bends cause no cracking or peeling—no loss of dielectric strength.

Dielectrically-Strong—All Grades conform to NEMA and MIL-I-3190 Standards.

Moisture-Resistant—Including resistance to salt water, mild alkalis and acids.

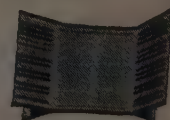
Flame-Resistant—Standard burning test is 45 seconds to burn 1 inch. Can be made self-extinguishing on special order.

Cold-Resistant—Excellent resistance to chafing and abrasion, flexible to -35°C.*

*For temperatures down to -65°C., and for applications requiring extraordinary flexibility, we recommend our new Varglas Silicone Rubber sleeving and tubing. Inquiries invited.



Send for
FREE SAMPLES
Write today for free
folder containing 25 different
test samples of
Varflex insulating sleeving,
tubing, lead wire
and tying cord.



VARFLEX SALES CO. INC. 314 N. Jay St., Newark, N. J.

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SPACE/AERONAUTICS



A NEW DIMENSION IN COMPUTER TECHNOLOGY

Never has so vast and complex a project been undertaken in data processing and data communications. Billions of bits to be handled . . . information flowing in from hundreds of electronic sources, processed by digital techniques, displayed, solutions and commands issued . . . in precious seconds.

A very short time ago we were a newly created subsidiary of International Telephone and Telegraph Corporation. Today we are a purposeful engineering management group actively forging ahead with the myriad problems of our challenging project.

As systems manager we are charged with the development and production of a world-wide electronic control system which will transmit, process and display information required in

military operations — global, in seconds. This project demands a wealth of engineering imagination. It will result in creation of a wholly new technology in digital computer science.

If your interests as an engineer lie in electronic systems engineering, in data processing and communications, you will find in this project unusual opportunity to express imagination and creative competence, in a degree surpassing anything previously undertaken in computer engineering.

To obtain information on engineer openings write A. J. Crawford, Personnel Manager. A resume of your education and experience is essential. An interview will be arranged at your convenience.

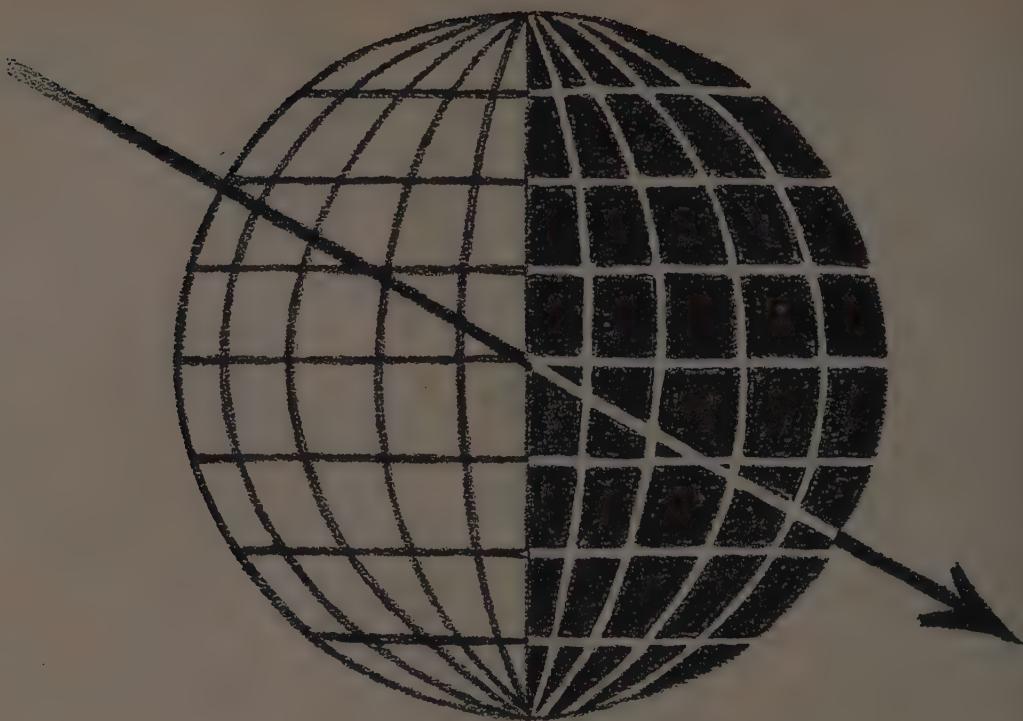


INTERNATIONAL ELECTRIC CORPORATION

Route 17 & Garden State Parkway, Paramus, New Jersey
A Subsidiary of International Telephone and Telegraph Corporation

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IT'S ALWAYS "WINTER" SOMEWHERE



Heating Blankets and other Woven Heating Elements by SAFEWAY can make your COLD problems OLD problems!

To keep sensitive equipment, fuels, propellants and lubricants at correct operational temperatures in any cold environment, controlled heat must be delivered with utmost dependability. SAFEWAY delivers it — *everywhere*.

Among the wide variety of heating blankets and woven-wire heating elements successfully engineered by SAFEWAY to meet tailor-made specifications are:

- heating blankets for honeycomb and metal-to-metal bonding
 - de-icing units for airfoil surfaces
 - heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft
 - radiant heating panels for industry
 - defrosting units for industrial and commercial refrigeration

FOR YOUR COPY OF A FACT-FILLED FOLDER, PLEASE WRITE:

If it has to be heated (and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems and — without any obligation — submit an appropriate recommendation.

Safeway

HEAT
ELEMENTS
INC.

680 Newfield Street • Middletown, Connecticut

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MEN AND IDEAS IN MOTION: AERONUTRONIC

This is Aeronutronic — men, ideas, and the tools for research. Aeronutronic — a dynamic new name in science — created by the Ford Motor Company to meet the demanding technological needs of a nation on the move.

Aeronutronic is moving into the future and moving fast. Space sciences, missile technology and space vehicles...computers, electronics...tactical weapon systems...these are major research,

development and manufacturing activities conducted at ASI's modern 200-acre Research Center under construction at Newport Beach, California.

Exceptional engineers and scientists are needed now. If you are forward-looking and want to be an important part of a forward-moving organization, you'll find a new challenge and rewarding future at Aeronutronic — *where men set ideas in motion.*

For information regarding positions, interests, facilities or products, write to Mr. K. A. Dunn, Aeronutronic Systems, Inc., Bldg. 13 1234 Air Way, Glendale, California, or call CHapman 5-6651.

AERONUTRONIC

a subsidiary of FORD MOTOR COMPANY

NEWPORT BEACH, GLENDALE, SANTA ANA AND MAYWOOD, CALIFORNIA

OFFICE OF ADVANCED RESEARCH • SPACE TECHNOLOGY DIVISION • COMPUTER DIVISION • TACTICAL WEAPON SYSTEMS DIVISION
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Special Solutions to Uncommon Problems in Flow Measurement

The metering of high strength hydrogen peroxide, an oxidant in the rocket boost engine of an advanced Navy weapons system, presented unusual problems. The characteristics of H_2O_2 severely limited choice of transmitter materials. In addition, requirements called for extreme accuracy, a low pressure drop and a sizeable, reliable signal in a package of minimum size and weight. Revere solved this problem with a flow-metering system utilizing materials compatible with H_2O_2 and engineered specifically for the density and viscosity of the fluid. This system provides, over the entire flow range, better than $\pm 1.0\%$ accuracy, less than 2.5 PSI pressure drop, and a modulated signal of 2.5 volts amplitude which requires no external amplification.

The H_2O_2 flowmeter is only one of the many specially designed Revere flow measuring units. Impeller meters and positive displacement meters, gravimetric meters for ground fueling and flowmeters for "buddy system" refueling ...all are engineered to meet specific requirements.



CALL ON REVERE ...
WHEN YOUR PROJECT RATES THE BEST
RATHER THAN "OFF-THE-SHELF" TREATMENT
when you want engineering abilities and specialized facilities
in the fields of:

- Liquid Level Indication and Control
- Flow Indication and Control
- Flow Measurement
- High Temperature Wire and Cable
- Thermocouple Wire and Cable
- Thermocouples, Harnesses and Leads
- Electrical and Molded Harnesses
- Weight, Force and Thrust Measurement
- Determination of Center of Gravity
- Strain Gage Load Cells

**REVERE
CORPORATION
OF AMERICA**

Wallingford, Connecticut

A SUBSIDIARY OF NEPTUNE METER COMPANY



Write in No. 183 on Reader Service Card at start of Product Review Section

PRODUCT REVIEW

TRANSMITTER is very compact

The Model IL-101 subminiature transmitter is a very compact device designed for exceptional frequency stability under high-acceleration space vehicle environmental conditions, says Aeronutronic Systems, Inc., Dept. S/A, 1234 Air Way, Glendale, Calif. The transistor transmitter features minimum size and weight, low power consumption, and high efficiency.

Power is provided to facilitate tracking at a range of one earth radius or more. Frequency range is 108 mc, ± 500 cps, with a long term (24-hr) stability of three parts in 10^6 . Power output is 150 plus or minus ten mw, and overall efficiency is about 20 percent. The five oz unit is rated for normal operation at an operational temperature of zero to 55 deg C, linear acceleration of 200 g's, and shock of 1000 g's.

Write in No. 210 on Reader-Service Card

AMPLIFIERS for vibration testing



Continuous outputs of 50 and 100 kva, respectively, with total plate dissipation of 100 and 150 kw, have been achieved in the Models T996 and T999 vibration test system, wide-band amplifiers. The larger of the two provides random motion of over 53,000 lbs peak force and 25,000 lbs vector sine, says MB Mfg. Co., Dept. S/A, P.O. Box 1825, New Haven, Conn.

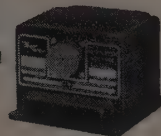
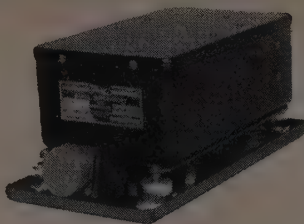
The T996 provides power for systems from 7000 to 21,500 lbs vector sine wave, with random performance up to 32,000 lbs peak. Both amplifiers are designed for remote operation and are equipped with sequential interlocks to assure proper operation. The units employ low- μ output tubes that are used in push-pull parallel with over 15-db feedback. The design permits full output with power factors from 0.2 lag to unity and 0.2 lead.

Write in No. 211 on Reader-Service Card
more on page 240

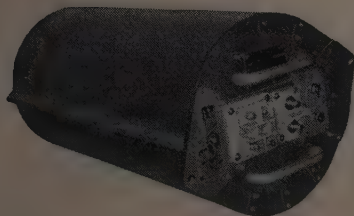
HIGH TEMPERATURE AC GENERATING SYSTEMS



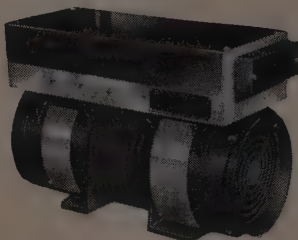
AC Generators



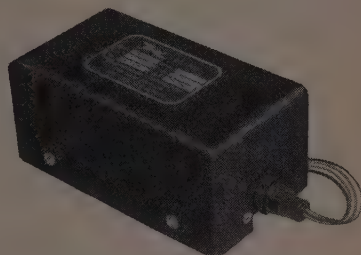
AC Voltage Regulators and SYSTEM COMPONENTS



SPECIAL ENVIRONMENTAL FREE INVERTERS

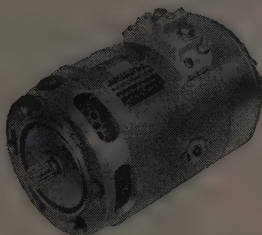


HIGH-ALTITUDE AND MISSILE INVERTERS

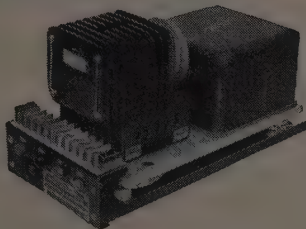


STATIC AC AND DC POWER SUPPLIES

HIGH TEMPERATURE DC GENERATING SYSTEMS



DC Generators



DC Voltage Regulators
and
CONTROL PANELS

BENDIX RED BANK—UNEXCELLED PERFORMANCE

AROUND THE



AROUND THE



There's no questioning the quality of electrical power equipment when it's made by Bendix Red Bank. The proof is in acceptance—almost universal acceptance. Twenty-four hours a day, in countries around the world, equipment like that shown above is proving that skillful design and expert engineering (plus an almost unmatched quality control system) can build an international reputation for dependable

performance. If you can use quality like this, call on us for recommendations. Write today for brochure detailing our engineering, production, and service facilities, RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

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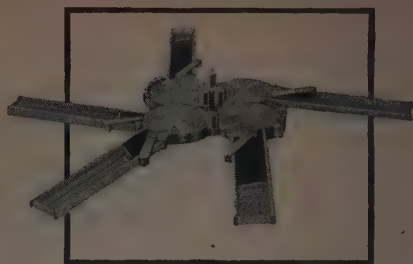
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A system with *complete files, complete data and complete processing . . .* to handle all operations.

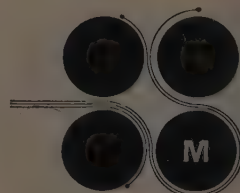
It's a proven fact . . . that of the total work necessary to put a missile into the air, a staggering 90% is primarily logistical and involves the control of many individual maintenance parts. This figure becomes compounded as the number of inactive, but ready-to-fire missiles increases . . . and keeping track of their individual needs becomes a herculean task.

It is clear that an efficient system of organizing, filing and searching great masses of data at high speeds, and at realistic costs is necessary. *The Magnavox Company* answers the need for "discrete" unit data record handling for both government and industry with *Magnacard*.

You are invited to investigate and make use of these new techniques . . . write today for illustrated brochure.



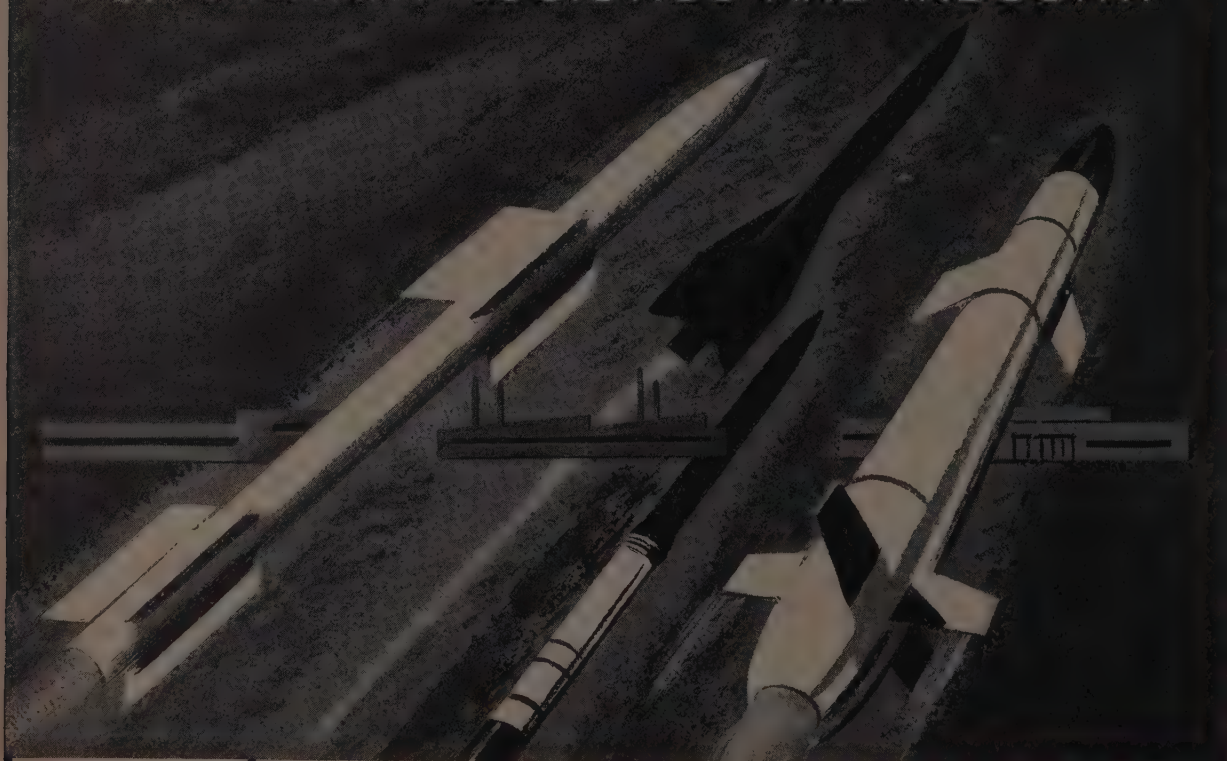
Magnacard



DATA HANDLING EQUIPMENT BY

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FOR MILITARY LOGISTICS AND INDUSTRY



COMMUNICATIONS



RADAR



DATA HANDLING



ASW



MISSILES

THE MAGNAVOX CO. • DEPT. 40 •

Government and Industrial Division

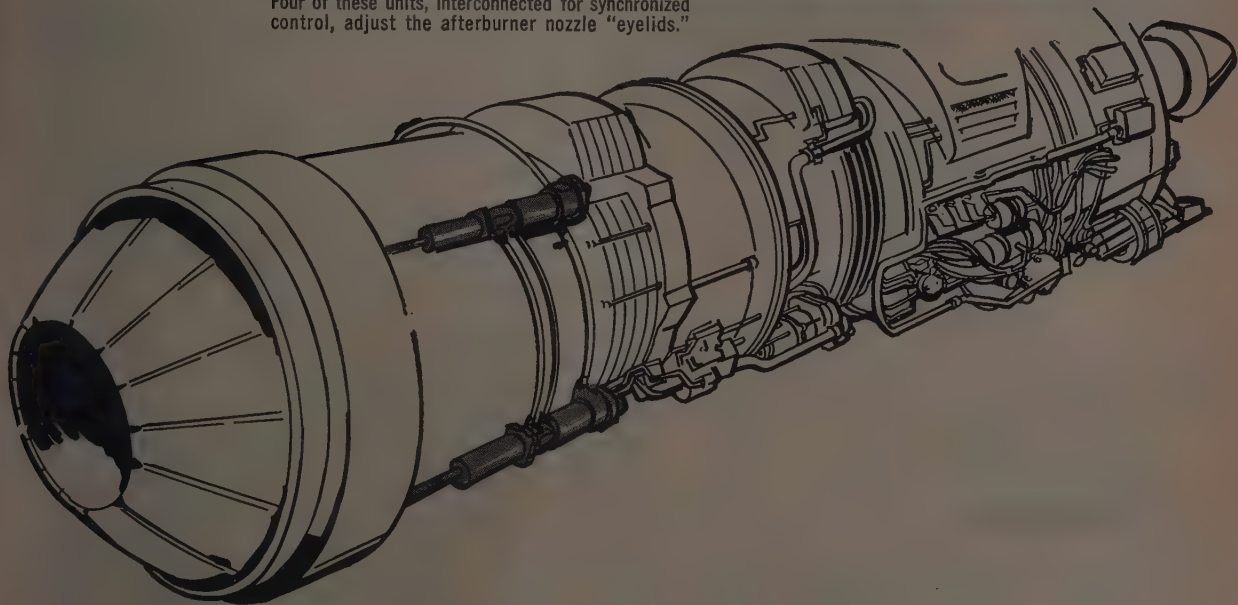
• FORT WAYNE, IND.

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New
steels are
born at
Armco

Four of these units, interconnected for synchronized control, adjust the afterburner nozzle "eyelids."



Why Armco 17-4 PH Stainless Steel Assures Dependable Thrust Control

Positioning afterburner "eyelids" to control jet engine thrust demands reliable delivery of power under severe conditions. Hydraulic actuators for this service, operating at pressures to 3000 psi and at ambient temperatures of -65 to 800°F not only must be efficiently designed, but constructed of metals with unusually high mechanical properties and corrosion resistance.

That's why the manufacturer of this afterburner nozzle actuator, now in use on a new high-thrust engine, selected Armco 17-4 PH Stainless for the actuating rod, cylinder forging, and other severely stressed parts. It provides the high strength-weight ratio and hardness at elevated temperatures, the good corrosion resistance, and the excellent fabricating characteristics required to economically produce a smooth-acting, powerful, dependable unit.

Meet Aircraft and Missile Requirements

Armco's space-age metals—17-4 PH, 17-7 PH and PH 15-7 Mo Stainless Steels—are used extensively in military and commercial aircraft and missiles for airframes, skins, tanks, power plants and accessories. They help satisfy the need for metals that withstand high stresses and heat and can be fabricated easily by standard production methods.

For design data and fabricating information on these special Armco Steels, just write Armco Steel Corporation, 1219 Curtis Street, Middletown, Ohio.

ARMCO STEEL



Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

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NEW AGASTAT®



HAS LONGER OPERATING LIFE

The Agastat time/delay/relay has been completely re-designed, inside and out, to make every moving part last longer and operate more reliably. Here are some other important advantages:

- Dial adjustment for ease and accuracy
- Five timing ranges, covering an overall range of from 0.08 seconds to 15 minutes
- Timed intervals remain the same through repeated readjustments
- Integral wiring diagram and calibration plate
- Measures only 4-9/16 x 2-9/16 x 2-5/8"
- All contacts are flexible contacts
- Contacts are larger for fast heat dissipation

Write for details and application engineering assistance to Dept. A32-219.

AGA
DIVISION

Elastic Stop Nut Corporation
of America

1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in Pneumatic Timing

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PRODUCT REVIEW

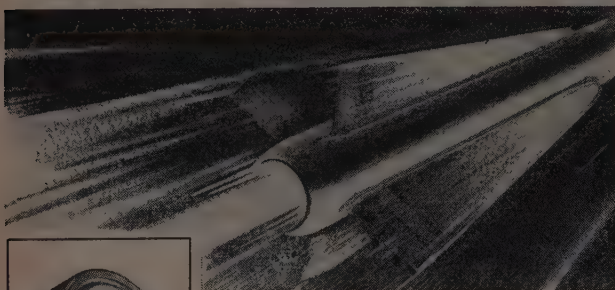
RATE GYROS in small sizes



Models RC-10S20 and R 99S86 are, respectively, subminiature and miniature floated, viscous-damped rate gyros. They are designed for use in the environments of high-performance aircraft and missile applications, according to Daystrom Pacific, Dept. S/A, 9320 Lincoln Blvd., Los Angeles 45, Calif.

Ac spin motors and microsynchronous pickoffs are used in the instruments, which feature low threshold, minimum hysteresis, high natural frequency, and excellent linearity. Dimensions of the subminiature model are a case length of 2½ in. and dia of 1¼ in. The other unit is 3½ in. long and has a 2½-in. dia.

Write in No. 212 on Reader-Service Card



Minute Giants...

B.M.B. Miniature Bearings to the highest precision limits, are made specially for Space craft, missile or ground support instrumentation.

Stainless Steel for servo application, B.M.B. have supplied miniature bearings to the American market for the past ten years.

Miniaturization plus reliability equals faultless functioning equals B.M.B. Miniature Bearings.

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this **NO-COST TEST** OFFER
has **CONVINCED** thousands
... send for YOUR FREE
"TEST CAN" of C-5 "hi-temp"
ANTI-SEIZE THREAD COMPOUND!



For one hundred and one aircraft uses such as slip joints, spark plugs, manifold studs, turbo blowers, jet engines, etc.

Try C-5 and see why leading aircraft manufacturers and thousands of industrial users have made it a part of their regular preventative maintenance program.

C-5 **HIGH-TEMP**

- ✓ Ends Seizing and Galling even up to 1800°F.
- ✓ Reduces Wrench Torque
- ✓ Ends Stud Breakage
- ✓ Permits Repeated Re-use
- ✓ Speeds Assembly and Disassembly
- ✓ Protects Stainless Steel at all Temperatures

ANTI-SEIZE THREAD COMPOUND

C-5's exclusive colloidal copper formula separates mating metal threads and surfaces with cushioning, protective copper plating. C-5 prevents galvanic action and eliminates pitting even when

dissimilar metals join. On mating metal surfaces, C-5 saves gaskets and countless man hours.
WRITE TODAY... For Your FREE Test Sample Can of C-5.

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Chicago 80, Ill.

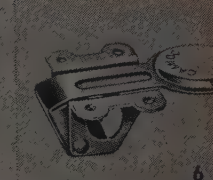
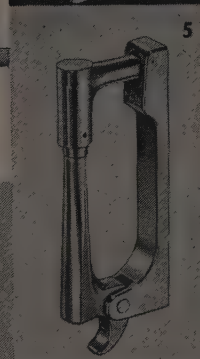
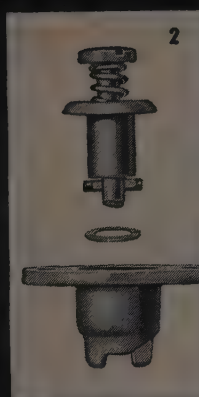
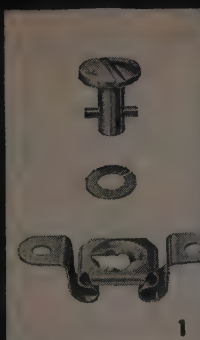
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SPACE/AERONAUTICS

specialists in fasteners for industry

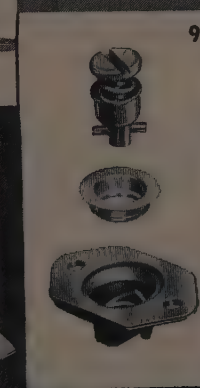
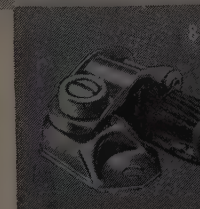
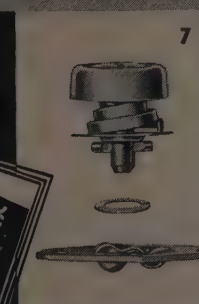
speed · versatility · positive performance

Outstanding creative engineering at Camloc has produced a variety of fastening devices. For access panels, doors, other closures; for simplified replacement of components and sub-assemblies. There are other fastening devices, designed for a variety of specialized applications, all of them retaining the three important features that characterize all Camloc products... speed, versatility and positive performance.



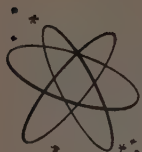
1. SF fastener for thin materials
2. 2600 Series Quarter-Turn
3. Miniature Toggle Tension Latch
4. 91F Heavy Duty Quarter-Turn
5. Electronic Chassis Latch
6. Push Button Latch
7. 28F Series Quarter-Turn
8. 7C Harness Clamp
9. 4002 Series Quarter-Turn
10. SPF (Stressed Panel) Fastener

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Write in No. 190 on Reader Service Card at start of Product Review Section



data preview

TRANSMITTING TUBES—Bulletin PT-24 (8 pages) is a guide to all electronic tubes currently available from General Electric Co., Dept. S/A, Schenectady 5, N. Y., for transmitting and allied applications.

Write in No. 213 on Reader-Service Card

ALLOYS—A two-color chart tabulating the composition and physical properties of alloys commonly used for investment castings is available from Alloy Precision Castings Co., Dept. S/A, Cleveland 11, Ohio. It covers both ferrous base and non-ferrous alloys.

Write in No. 214 on Reader-Service Card

ATC TRANSPONDERS—Collins Radio Co., Dept. S/A, 855 35th st. N. E., Cedar Rapids, Iowa, is offering a booklet about the 621A-2 ATC transponder.

Write in No. 215 on Reader-Service Card

NEUTRON SHIELDING—A technical memorandum on the welding of Boral Sheet and plate, a neutron shielding material for atomic power plants, has been prepared by Aluminum Co. Of America, Dept. S/A, New Kensington, Pa. Tungsten arc welding and consumable electrode techniques are discussed, along with the performance of welded joints.

Write in No. 216 on Reader-Service Card

RECORDERS—Scientific Atlanta Inc., Dept. S/A, 2162 Piedmont Road, N. E., Atlanta 9, Georgia, is issuing a folder describing the S-A antenna pattern recorders and auxiliary equipment.

Write in No. 217 on Reader-Service Card

RADIATING SYSTEMS—RS 100 is a 32-page brochure describing the facilities and products of the Radiating Systems & Components Div., Electronic Specialty Co., Dept. S/A, 5121 San Fernando Rd., Los Angeles 39, Calif. Information is included on matched radiating systems as well as on components for antennas, antenna arrays, coaxial switches, power dividers, and other devices.

Write in No. 218 on Reader-Service Card

BRAZING—"Brazing News #79" is a four-page brochure on the advantages and techniques of brazing, as outlined by Handy & Harman, Dept. S/A, 82 Fulton St., New York 38, N. Y. Examples of the use of silver-brazing alloys are included.

Write in No. 219 on Reader-Service Card

SOCKET SCREWS—Microsize Unbrako socket head cap and set screws with Nylok self-locking feature are the subject of a new bulletin by Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa. Full specifications and ordering information are given in the four-page illustrated publication.

Write in No. 220 on Reader-Service Card

PRECISION COMPUTER—An illustrated 18-page brochure and folder is now available from Mid-Century Instrumental Corp., Dept. S/A, 611 Broadway, New York 12, N. Y. It describes the MC-5800 master precision analog computer. Fourteen pages of specs are included.

Write in No. 221 on Reader-Service Card

CAPTIVE NUTS—Bulletin 58-2, a four-page brochure describing wear-resistant, steel threaded inserts for use in aluminum or brass, is available from National Co., Inc., Dept. S/A, 61 Sherman St., Malden 48, Mass. Five types of captive nuts are catalogued, along with a line of studs.

Write in No. 222 on Reader-Service Card

RF CHOKES—A technical data sheet released by Essex Electronics, Dept. S/A, Berkeley Heights, N. J., gives details on the electric parameters of the company's line of RF chokes.

Write in No. 223 on Reader-Service Card

CHECK VALVE—Data Sheet F-8532, from Barber-Coleman Co., Dept. S/A, Rockford, Ill., describes its new 2½ inch pneumatic check valve, designed to check rapidly reversing high temperature, high pressure air surges, and to withstand forces caused by extremely rapid air reversals.

Write in No. 224 on Reader-Service Card

DIGITAL TEST UNITS—Specs and prices of digital test equipment from Digital Equipment Corp., Dept. S/A, Maynard, Mass., are given in a four-page folder.

Write in No. 225 on Reader-Service Card

HOSE FITTING—A new catalog on Flexon aeronautical synthetic and T hose assembly fittings has been issued by Flexonics Corp., Dept. S/A, Maywood, Ill. The fifteen-page, thumb-indexed Catalog A-184 shows hose construction and design details on both factory and reusable fittings.

Write in No. 226 on Reader-Service Card

SERVO MOTORS—Bulletin 385A gives application data on servo motors from Norden Div., United Aircraft Corp., Dept. S/A, Commack, N. Y. Sizes 08 to 23 are covered.

Write in No. 227 on Reader-Service Card

TITANIUM—An eight-page brochure describing the properties and corrosion resistance of pure titanium, is available from Malory-Sharon Metals Corp., Dept. S/A, Niles, Ohio. Typical chemical compositions and mechanical properties are tabulated in the booklet.

Write in No. 228 on Reader-Service Card

FM ANALYSIS—The theory and practice of FM analysis are discussed in the latest issue of *The Panoramic Analyzer*, published by Panoramic Radio Products, Inc., Dept. S/A, 514 S. Fulton Ave., Mt. Vernon, N. Y. Basic FM theory, complex modulation, FM spectrum measurements, and combined AM and FM are covered.

Write in No. 229 on Reader-Service Card

CORROSION PREVENTATIVES—Data on 20 corrosion preventatives, including solvent cutbacks, petrolatum barriers, general purpose preservatives and engine preservation lubricants are presented in a chart of military-specification corrosion preventatives for industrial and military use by Pennsylvania Refining Co., Dept. S/A, Butler, Pa.

Write in No. 230 on Reader-Service Card
more on page 246



MICRO SWITCH Precision Switches



Toggle and rocker actuated switches that provide better answers to a variety of switching problems

This group of thirteen switches represents well over seven hundred switches in three series. There's a complete selection of contact arrangements, mounting provisions, and choice of single, double, or 4-pole construction.

"TP" Series—rocker actuated, sealed actuator and cover. Available with translucent keys for use with edge-lighted panels to give visual indication of position, or with transparent keys that permit insertion of labels. Integral terminals. These switches promote neat panel appearance. Data Sheet 141.

"TL" Series—toggle switches with sealed actuators and covers. Meet Specification MIL-S-3950A. Integral terminals. Diallyl phthalate cases reduce carbon tracking at altitude, and minimize moisture absorption. Series includes pull-to-unlock toggles, with a positive lever lock that requires a definite pull to change toggle position. Knobbed levers permit use with gloved hands. Data Sheets 139 and 142.

"TS" Series—toggle switches that meet Specification MIL-S-3950A and, *in addition*, offer outstanding features. Sealed toggle lever. Riveted solid

silver contacts. Maximum over-surface creepage and clearance distances. Momentary versions are built without return springs in order to eliminate a source of early failure. Described in Catalog 73—which also includes miniature and subminiature toggle switch assemblies.

All these switches are manufactured with extreme care and precision from the finest materials, with due regard for important details that mean easier mounting and wiring, and longer switch life.

Send for Data Sheets and Catalogs listed above. Engineering assistance on switch applications is available from the MICRO SWITCH branch office near you.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell

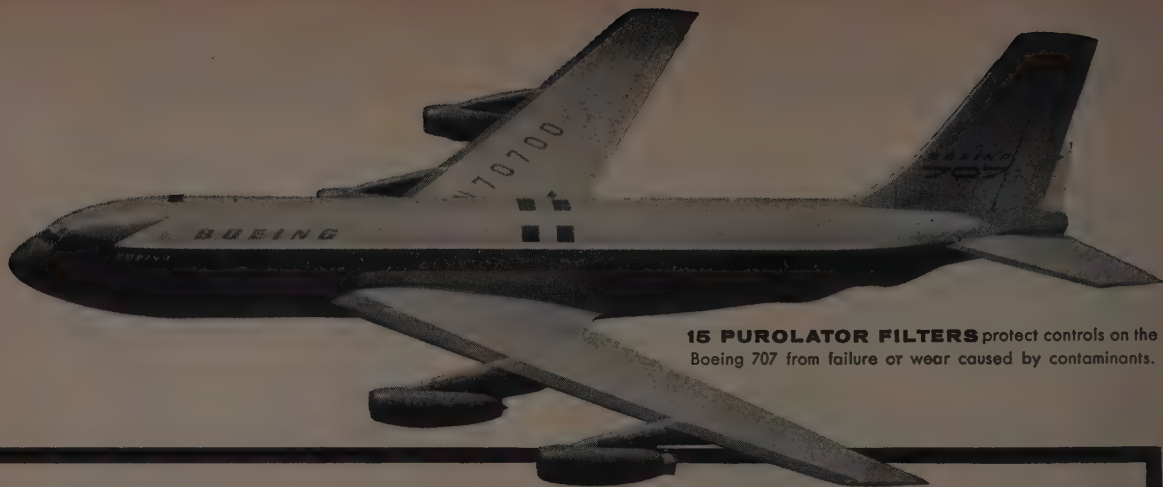
In Canada: Honeywell Controls Limited, Toronto 17, Ontario



Honeywell

MICRO SWITCH PRECISION SWITCHES

Write in No. 191 on Reader Service Card at start of Product Review Section



15 PUROLATOR FILTERS protect controls on the Boeing 707 from failure or wear caused by contaminants.

NAME YOUR FLUID ...

NAME YOUR APPLICATION

**PUROLATOR HAS THE FILTER YOU NEED FOR
LUBRICANTS • FUELS • HYDRAULIC FLUIDS • AIR**

There are 15 Purolator filters on the big new Boeing 707 Jet transport. There's a Purolator Filter on the hydraulic boost system on Bell's new 4-place Ranger helicopter. There's a good reason for this increasing attention to filtration on *all* types of aircraft. It's simply this: every engine, every instrument, every control is more reliable when it's protected by effective filtration. That's why your design deserves the best protection against all contaminants that threaten optimum aircraft performance. And there's no better filtration obtainable

than Purolator.

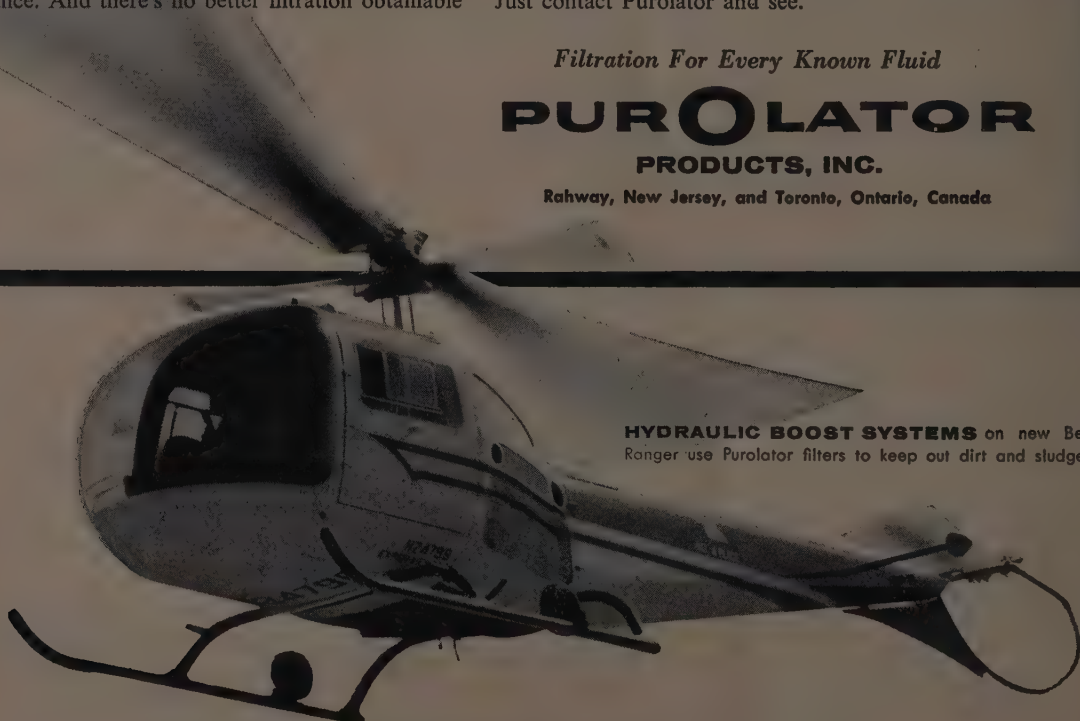
In fact, in Purolator's standard line you can find a filter that satisfies any combination of the five main design variables which determine the right filter for a specific need: sizes of particles to be removed, flow rate vs. pressure drop, fluid to be filtered, system maximum operating pressure, and system extreme temperature range.

It's not likely that your problem — no matter how unusual — is too special for a standard Purolator unit. Just contact Purolator and see.

Filtration For Every Known Fluid

PUROLATOR
PRODUCTS, INC.

Rahway, New Jersey, and Toronto, Ontario, Canada



HYDRAULIC BOOST SYSTEMS on new Bell Ranger use Purolator filters to keep out dirt and sludge.

Write in No. 192 on Reader Service Card at start of Product Review Section

SPACE/AERONAUTICS



New SPS super high strength shear fasteners save you 25-50% in shear bolt weight

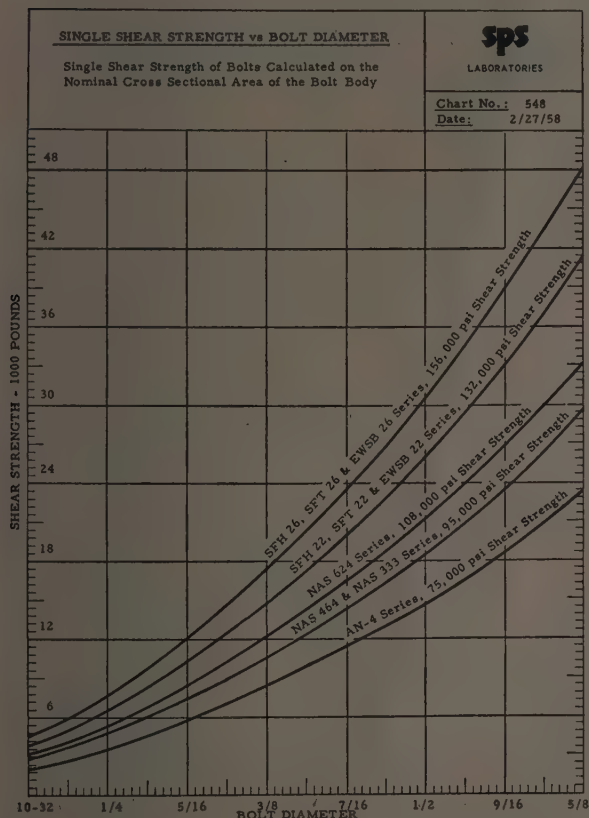
132,000 and 156,000 psi units are strongest standard shear fasteners ever offered

New SPS super bolts and companion locknuts are the strongest shear fasteners ever offered the aircraft-missiles industry, permit significant reductions in size and weight of threaded joints. Three different wrenching configurations are available, any one of which will induce over 50% of ultimate fastener strength. Units are serviceable to 550°F.

These new SPS shear bolts are 39 to 64% stronger than the best standard shear fasteners now in use. They automatically save you 25 to 50% in shear bolt weight, because they can be substituted for conventional fasteners one to two diameter sizes larger...with no compromise in reliability.

For example, one of the new 1/2 in. diameter, 156,000 psi shear bolts, capable of design loading of 30,000 lb., does the structural job of a 5/8 in. NAS type weighing nearly 30% more. On a large airframe this can mean a saving of several hundred pounds. Further, the use of smaller fasteners often permits miniaturization of related parts in a joint, resulting in additional weight savings.

The new bolts are forged from 5% chrome high strength steel, then heat treated to 220,000 psi tensile for the 132,000 psi shear series and to 260,000 psi tensile for the 156,000 psi. Both series are available in standard sizes #10-32 through 5/8-18, with companion locknuts of new design. The 132,000 psi shear bolts have a cadmium-fluoborate plating, the 156,000 are vacuum cadmium plated. For complete information, write Aircraft/Missiles Division, STANDARD PRESSED STEEL Co., Jenkintown 54, Pa.



Greater shear strength. Graph shows shear strength in pounds for various diameter sizes of different shear bolts. Top two curves plot the new SPS super high strength shear bolts, available in 132,000 and 156,000 psi series. Remaining curves represent current aircraft industry standards.

HIGH RELIABILITY

SPS research is continually developing fasteners with higher standards of predictable performance. By installing SPS high-reliability fasteners in your assemblies, you increase overall product reliability.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

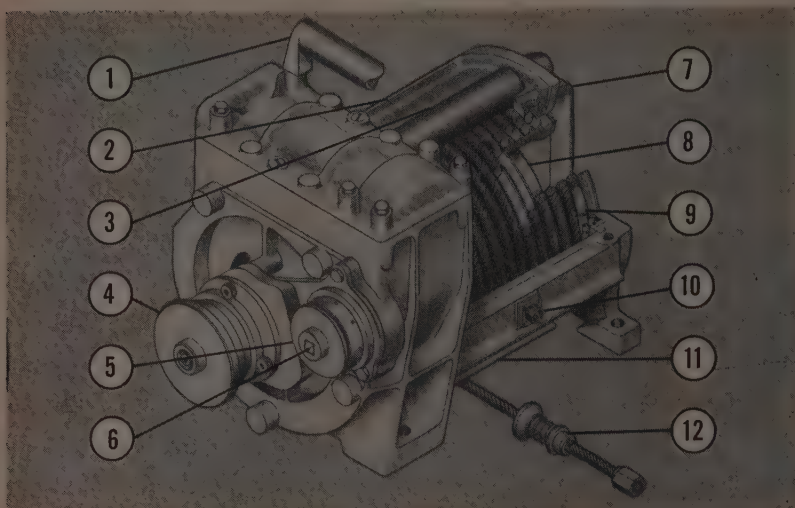
We also manufacture precision titanium fasteners / write for free booklet

SPS Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. •
Columbia Steel Equipment Co. • National Machine Products Co.
• Nutt-Shel Co. • SPS Western • Standco Canada Ltd. •
Unbrako Socket Screw Co., Ltd.

Write in No. 193 on Reader Service Card at start of Product Review Section

Lightweight winch... with a 3 ton capacity



The Model 61-M1 from **ALL AMERICAN ENGINEERING**

- | | | |
|-----------------------|-------------------------|--------------------------|
| ① CARRYING HANDLE | ⑤ CLUTCH | ⑨ CABLE ANCHOR FITTING |
| ② DRUM COVER | ⑥ HAND CRANK ADAPTER | ⑩ LIMIT SWITCH CONNECTOR |
| ③ ANTI-FOULING ROLLER | ⑦ MOTOR PULL-OUT HANDLE | ⑪ REEL-IN LIMIT SWITCH |
| ④ BRAKE | ⑧ MOTOR | ⑫ LIMIT SWITCH BUMPER |

This light self-powered winch with a 6,000 lb. lifting capacity is a new addition to the All American lightweight winch family. Powered by a fully enclosed 400 cycle motor, the Model 61-M1 winch is small enough, light enough at less than 50 pounds to be carried about . . . big enough for countless airborne, flight line and maintenance jobs.

Flexibility is a basic part of the design. Variations permit many load-speed combinations. 28 Volt DC or hydraulic drives can be substituted. Unit can be flange, base or suspension mounted — winches can be used in multiples from a single control head, also available from AAE.

The AAE Model 61-M1 is ideally suited for all these jobs:

Aircraft engine installation, changing • Transport cargo handling
Bomb loading • Ammunition handling • Helicopter applications
In-flight cargo handling, rescue, towing, and many others.

Standard specifications:

Cable Load — 6000 lbs. • Reel-in Rate — 10'/min.

Ultimate Load — 14,500 lbs.

Designed and built to meet MIL-E-5272A

To get all the facts on the Model 61-M1 lightweight winch, including life and duty cycles for your specific application, write to:

AAE
ALL AMERICAN ENGINEERING COMPANY
RESEARCH • DESIGN • MANUFACTURE
Box 1247, DuPont Airport • Wilmington 3, Delaware

West Coast Sales Representative: Forsnas Engineering Company, 1838 Flower Street • Glendale, California
Write in No. 195 on Reader Service Card at start of Product Review Section

DATA REVIEW

PULSE TRANSFORMERS—Bulletin PT 315, issued by Acme Electric Corp., Dept. S/A, Cuba, N. Y., gives specs on six types of sub-miniature and miniature pulse transformers.

Write in No. 231 on Reader-Service Card

LOCKNUTS—A four-page folder that catalogs lightweight forged locknuts is available from Standard Pressed Steel Co., Box 879, Dept. S/A, Jenkintown, Pa. The cadmium-plated hex nuts are self-locking and said to be 49 per cent lighter than standard counterparts.

Write in No. 232 on Reader-Service Card

WIRES—Properties and applications of cold-drum fine wires are described in a new booklet by Parts Div., Sylvania Electric Products Inc., Dept. S/A, Warren, Pa., in a new booklet. Alloy, plated, and clad wires are covered.

Write in No. 233 on Reader-Service Card

SYSTEMS—Its capabilities in the fields of aircraft, missile, ordnance, and support systems are outlined in a four-page brochure by Rheem Mfg. Co., Dept. S/A, 11711 Woodruff Ave., Downey, Calif. "Performance Pays" includes information on Rheem's honeycomb structures facility and pressure vessels.

Write in No. 234 on Reader-Service Card

OIL - FILLED POTENTIOMETERS

—Three liquid-filled potentiometers now produced by Helipot Div., Beckman Instruments, Inc., Dept. S/A, Fullerton, Calif., supply subject matter for Data Sheet 1482, a seven-page technical summary.

Write in No. 235 on Reader-Service Card

BRAZING FITTING—Braze-lok, a fitting for brazed tube connections that makes for permanent tubing joints in certain high pressure service, is described in Catalog 4375, available from Parker-Hannifin Corp., Dept. S/A, 17325 Euclid Ave., Cleveland 12, O. The brazing fitting can be used in the missile, aircraft, petrochemical and other fields.

Write in No. 236 on Reader-Service Card

TUBES—The complete line of electronic tubes manufactured by Central Electronics Mfrs. Div., Nuclear Corp. of America, Dept. S/A, Denville, N. J., is described in six-page Catalog 2220. Power triodes, rectifier and clipper diodes, gas noise source tubes, TR tubes, pressurized waveguide windows, and ionization gage tubes are covered.

Write in No. 237 on Reader-Service Card



solving critical control problems for space-age progress

WHITTAKER GYRO

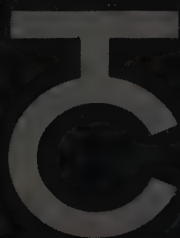
BRUBAKER ELECTRONICS

DATA INSTRUMENTS

ENGINEERING SERVICES

WHITTAKER CONTROLS

NUCLEAR INSTRUMENTS



TELECOMPUTING CORPORATION

915 NORTH CITRUS AVENUE

LOS ANGELES 38, CALIFORNIA

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FROM EXPERIENCE

COMPETENCE

TO
MEET
YOUR
MOST
CHALLENGING
PROBLEMS

ASTRONICS • AVIONICS • INSTRUMENTATION

Whether you're pondering a perplexing chess gambit or developing a data acquisition system . . . experience makes the difference.

Radiation, Inc., a pioneer in relatively new areas of research and development, offers you practical experience coupled with skill and training. But, even more, Radiation offers you the verve and vigor that often finds the solution beyond existing horizons.

If you seek a firm with *proven* solution-finding skills, send for our record of achievement.

Simply specify the field of endeavor that interests you most — Antenna Development, Telemetry, Data Systems, Missile Checkout, Instrumentation, Radar Reflectivity, or Counter-measures.

***The "Chess Pieces" shown are Radiation's telemetry tracking antenna, Vanguard data processing trailer, missile checkout system.



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SPACE/AERONAUTICS

EFFICIENT, COMPATIBLE AUXILIARY POWER SYSTEMS...

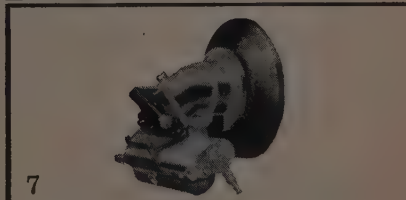
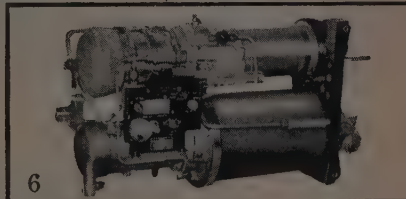
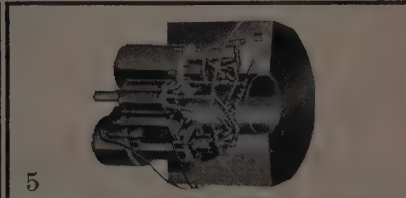
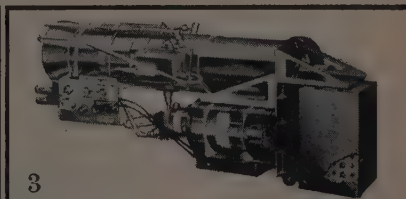
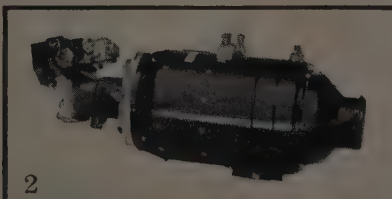
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Missile progress demands unquestionable reliability, maximum efficiency and compatibility of the system with the overall vehicle. These rigid standards are being met by Vickers with *missile industry-tailored* R & D, engineering, production and service capabilities blended with extensive experience gained from a large number of successful accessory applications on a majority of the current production missiles.

*Typical Vickers designed
APS's include:*

1. Hot Gas Systems
2. Close Frequency Systems
3. Battery Powered Systems
4. Door Mounted Systems
5. Blast Tube Configurations
6. Turbine Powered Systems
7. Flywheel Systems



Using proven components as building blocks, Vickers can shorten APS development time and speed delivery . . . all with the assurance of dependability. These advantages are passed on to you whether your specifications call for one or any combination of the following:

- TEMPERATURE TOLERANT SYSTEMS
- HIGH SPECIFIC POWER
- MAXIMUM EFFICIENCY
- HIGH OR LOW DRIVE SPEEDS
- CLOSE FREQUENCY CONTROL
- ACCURATE VOLTAGE REGULATION

For further information contact the nearest Vickers Sales and Service Office or write for *Bulletin No. A-5236*.

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3201 Lomita Blvd., P.O. Box 2003 • Torrance, Calif.

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letters to the editor

Change-over to metric?

I strongly support your interest in changing our system of measurement to the metric (*"Change-Over to the Metric System?"*, Dec. '58, p. 8).

Actually, the English system can give the necessary precision as long as conversion units between the yard and the meter are determined with sufficient accuracy and as long as the English system is used consistently. The awkwardness of the notation, the possibilities for errors in manipulation of English system units, and the confusion which is almost inevitable in conversion . . . all these are unanswerable arguments in favor of . . . the metric.

I believe the cost factor in such a change has been over-rated, at least if an intelligent and gradual change-over program can be established.

Even such relatively insignificant technological trends as the increasing use of European automobiles should bring the significance of such a change close to home for the average American. This is increasingly a small world, and a minority hold-out against a standard of measurement does not seem to be at all progressive.

Bell Aircraft Corp.
Buffalo, N.Y.

Everett T. Welmers
Assistant to the President

Jungle of systems

Your December '58 editorial . . . certainly hits the spot.

The writer, who has had over 22 years' engineering experience ranging all the way from research [to] tool design and production planning . . . can only say: *Go to the metric system!*

However, strong exception is taken to the fact you state . . . the reason for going to the metric system is for precision. How can this be? Only a moment's thought will convince anyone that . . . it can be measured just as precisely with either the metric or English system.

The writer holds great admiration for Dr. Hubertus Strughold, having heard him lecture . . . but we are sure [he] would be the first to recognize that, indeed, by his standard of precision, we are better equipped thermally to send a man into space with the (English) Fahrenheit temperature scale than with the Centigrade scale, since the latter has a graduation only about half as often as the Fahrenheit scale—unless of course we resort to . . . the decimal point.

[My] present activity includes thermal studies for airborne electronic equipment which is a field bewildering to the English system. Continual conversions are required between degrees F and degrees C . . . It is unfortunate that often a half day's activity can be consumed in this jungle of systems . . .

When working from a technical magazine article, to a textbook, to customer requirements (usually Uncle Sam), to company standards, to vendor standards, we run the full gamut of this jungle and often double back several times.

. . . the military has it in its power to accomplish conversion by . . . starting it—not overnight—but by a planned program:

- Be consistent within the military (all branches) when writing specifications and in all publications.
- Be consistent within government (both civilian and military) activities.
- Gradually award "metricized" contracts in all new fields of endeavor which are gradually building up in manpower and facilities.

• Notify older established industries of a reasonable time limit for switch-over to metric production. (When machine tools are written off against military contracts, would be a good time.)

• Enact federal, state and local laws on a sliding scale basis that would permit the gradual change-over of the civilian usage. (This of course to be done by the population after receiving the guidance established by the military.)

David G. Lewis
Playa Del Rey, Calif.

Errors never corrected

Your editorial . . . about the metric system is to my mind the most important by far ever to appear in your publication.

I was raised with the metric system, and I have never been able to understand how a civilized nation like our's could possibly put up with the English system all this time.

It is not only the accuracy that is poor, but the fact that every engineering calculation requires the use of conversion factors for nearly every individual computation not only increases the labor, but is a constant source of error. Since many of these errors are never corrected, it means that the final answers often are incorrect solely on account of the system of units used. The cost of this is truly staggering . . .

Your editorial gives me hope that perhaps we will be able to make the change after all. It certainly is high time.

Phoenix, Arizona

N. O. Myklestad, Ph.D.

Wants to hear more

Relating to the editorial . . . we would very much like to hear more.

. . . An article in the National Bureau of Standards Technical News Bulletin (Mar. '58) by Dr. A. V. Astin, director of NBS, makes this statement: 'We thus have the anomalous situation in this country of a legalized system of weights and measures which is not in common use, and a customary system of weights and measures which has never been formally legalized.'

Industry, I feel, recognizes the inadequacy of the English system relating to fractional dimensioning which is brought about by mechanization and automatizing. Industry has created a dimensional standard based on subdividing the inch into four parts, or a basic incremental length of .025 in.

It would appear that this was an opportune time to consider metric dimensioning.

We would like to hear more about the precision requirements as mentioned by Dr. Hubertus Strughold in your article which he claims the English system cannot give. To what degree is this true?

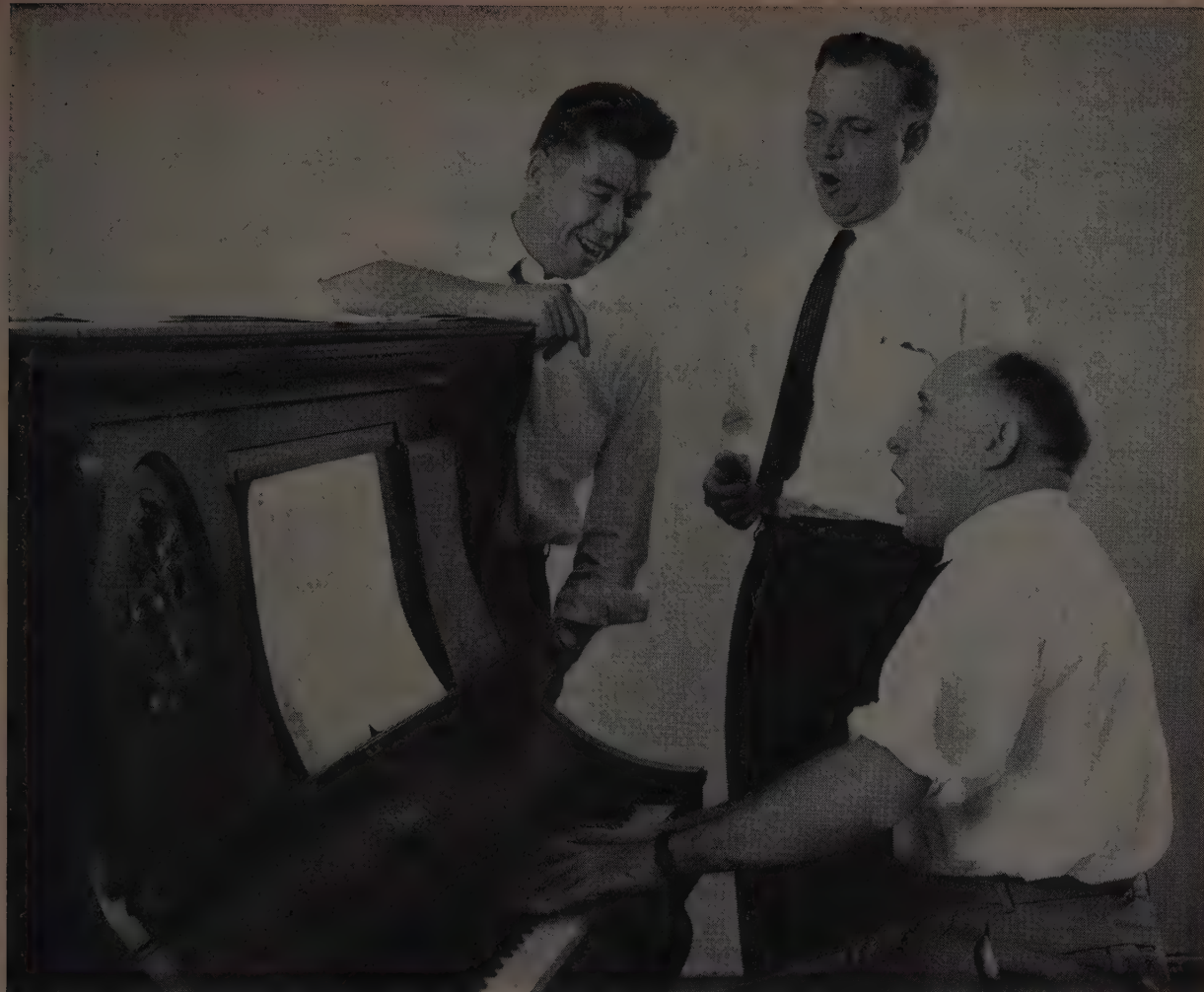
Unit Defense Electronic Div.,
Light Military Electronics Dept.
General Electric Co., Utica, N.Y.

W. J. Everts
Engineering Standards

Fractions make measurements difficult

Actually, the reasons why most scientists have used the metric system for so many years are: (1) Scales are readily available with decimal divisions; (2) only decimal point changes are needed between large and small units; (3) so

more on page 252



In Research—meet three men who get results

From high notes to high altitudes, harmony is the keynote of General Mills Research

Meet this harmonious trio of research scientists who spearhead progress in space technology at the Mechanical Division of General Mills. At the piano is Dr. Otmar Stuetzer, whose primary fields are physics and electronics research. Directly opposite him is Les Demorest, manager of atmospheric and measurements research. Sam Jones, standing to the left of the piano, is in charge of the section devoted to materials and mechanics research.

Scientists in our Research Department, like these three, help lay the groundwork for man's conquest of space. They work in harmony with each other and with the creative engineers and precision craftsmen who apply their findings.

Perhaps you can profit from teamwork like this. We'd like to work *with* you. **NEW BOOKLET RIGHT OFF THE PRESS** tells and shows the many ways we serve industry and the military. Write for your copy. Address Dept. AA-2



Dr. Stuetzer, Mr. Jones, Mr. Demorest work with the electron mirror microscope, a complex instrument which presents a picture of the electrical potential distributions on the surface of matter. The microscope was developed by General Mills for research and development work in solid-state and surface physics. It is the only one of its type in this country.

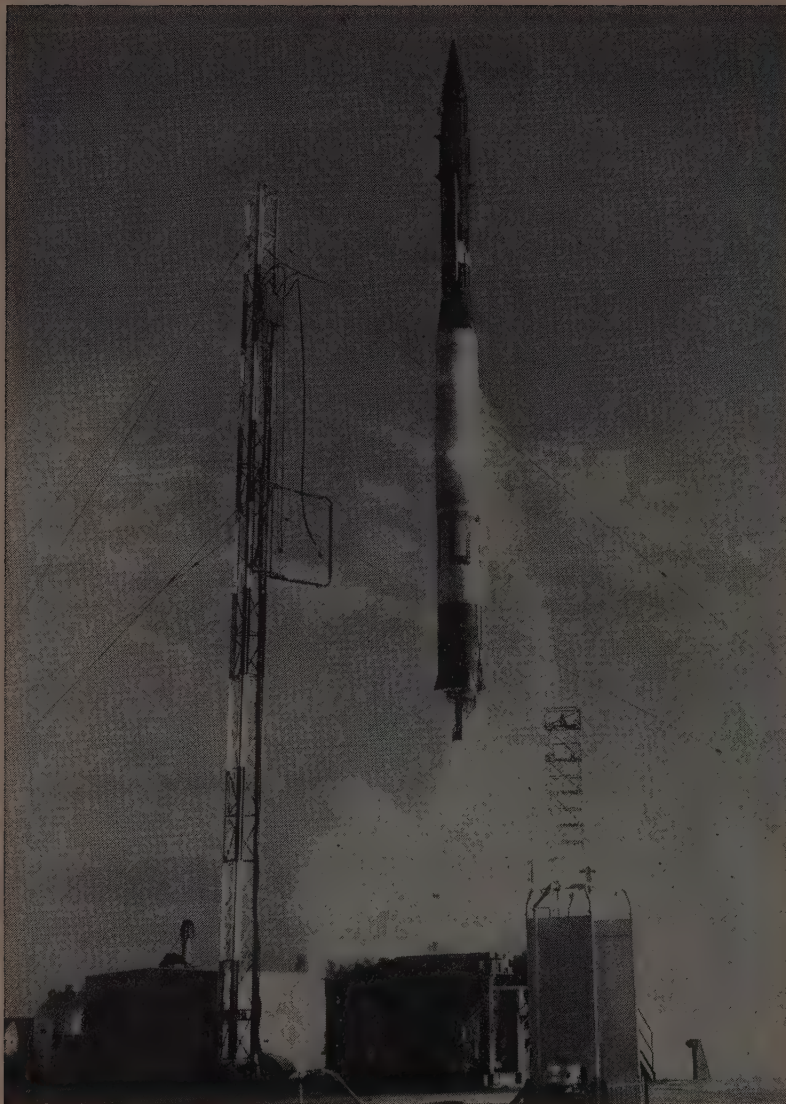
MECHANICAL DIVISION

1620 Central Avenue • Minneapolis 13, Minnesota



To wider worlds—through intensive research • creative engineering • precision manufacturing

Write in No. 199 on Reader Service Card at start of Product Review Section



Successful Vanguard equipped with Union miniature relays

March 17, 1958—Union Switch & Signal 6 PDT miniature relays functioned perfectly in the separation controls between the first and second, and the second and third stages . . . in the first stage propulsion unit . . . and in the third stage spin control assembly of the satellite-bearing Vanguard.

The Martin Company, builders of the Vanguard, chose these outstanding relays for their reliability . . . for

their simple, rotary design . . . and for the expert quality control associated with the established leader in electrical relay design—Union Switch & Signal.

The 6 PDT relay used in the Vanguard is just one of a complete line of dependable relays designed by Union Switch & Signal—"Pioneers in Push-Button Science." Write today for complete technical information.

"Pioneers in Push-Button Science"



UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY —

PITTSBURGH 18, PENNSYLVANIA

Write in No. 200 on Reader Service Card at start of Product Review Section

as to have values readily understood by all scientists.

Now actually machine tools graduated in inches—even if the sub-graduations were 1024ths instead of thousandths—can make as accurate parts as metric machines.

The big advantage countries using the metric system commercially have over us is, principally, the saving in time on the less accurate dimensions, for which many manufacturers are still using fractional dimensions. For instance, those using fractional scales have six units for making directly-read measurements, while those using decimal scales have but two. Also, arithmetic is more difficult when measurements are in fractions.

Why has industry been so slow in converting to the decimal system? True, our school systems are greatly at fault in lagging, instead of leading, in what they teach. Our managers of industry have been quick to buy labor-savings machines, even at high costs and employee re-training. Surely there are now no good reasons why the smallest manufacturer, or even the individual draftsman, should use scales of medieval design.

Also, our schools should place the emphasis on using decimal dimensions and stop teaching fractional equivalents and how to use fractional rules. These aren't needed.

T. R. James
Senior Consultant
Mechanical Div.

Engineering Research & Development
General Mills, Inc.,
Minneapolis, Minn.

Time wasted and accuracy lost

The subject of the metric system . . . is very dear to my heart. I came to this country from Germany 12 years ago, and it happens to be that I have been using the English system for just about the same length of time in my engineering work as I have used the metric system.

I found that much time is wasted and some accuracy lost when one uses the English system. As an example, . . . the computation of the Doppler frequency of a radar echo from an elevated moving object. The magnitudes which enter this computation and the commonly given units are speed in miles per hour (whether statute or nautical miles is not often stated and, therefore, further check is necessary), altitude in feet, ground range in miles (statute or nautical?), wavelength in cm, and velocity of light in statute miles per second. Thus, one has the statute and nautical mile, the foot, and the centimeter in one expression which requires three conversion factors of limited accuracy.

If all the data were available in the

metric system, conversion factors disappear or may only mean a shifting of the decimal point and the computation is faster and more reliable.

I believe that mental inertia is by far a greater hindrance to a change-over than cost. But if we start in the area of space technology, we have two facts in our favor. First, magnitudes are not firmly established in our minds; we all are in a process of learning, and the meanings of these magnitudes are so different from those we are familiar with in connection with earthbound situations that comparison does not mean much.

Second, the kind of people involved—engineers and scientists—are most open-minded to new developments. We also should realize that the over-coming of mental inertia and the cost of conversion is a one-time effort which will pay off in a never-ending and increasing interest. It will also take a burden off the shoulders of our youngsters who spend more time to understand and govern the English system than their counterpart in the metric system area. I also believe that there will be no time more appropriate for a change than today.

Dr. Herbert P. Raabe
Mechanical Division
General Mills, Inc.,
Minneapolis, Minn.

"Mostly nonsense"

Your editorial . . . regarding a change-over to the metric system is mostly nonsense.

Why change?

For precision—ridiculous, there is no difference. We use the inch as the basic measure and it comes as accurately subdivided as any other arbitrary standard.

The Reds took the German metric drawings and didn't have to do them over. Of course not; Napoleon didn't conquer Russia but the metric system did long ago.

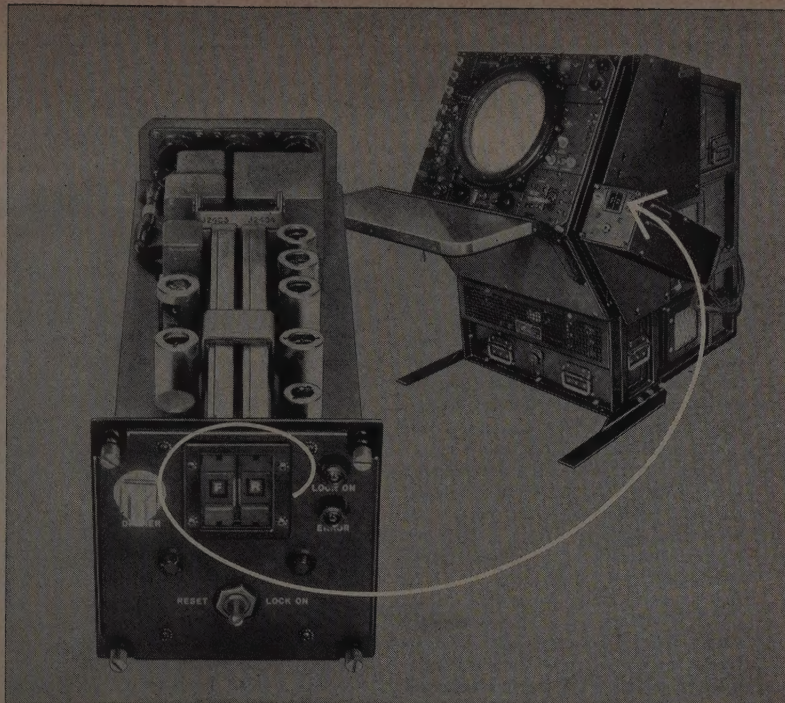
Easier relations between us and the metric nations—a good idea.

Military will save money—nonsense, all our tools are based on the decimal inch, i.e., the inch with decimal multiples and submultiples. Going to the meter instead of the inch would yield no accuracy gain, only much conversion before tooling.

In summary, we use a decimal system for length almost universally. Our arbitrary standard is the inch instead of the meter. We don't use rods, furlongs, etc. We seldom use feet. We use fractions for mental convenience (as do the metric countries). We use decimal time. We should change to a decimal weight measure.

R. C. Howard
Costa Mesa, Calif.

more on next page



Union Indicators help Hazeltine radar-display unit identify aircraft

The little box on the right side of the radar-display unit above warns of approaching aircraft. IFF response is displayed by Alpha-Numerical Indicators, made by Union Switch & Signal. Hazeltine Corporation, Little Neck, N. Y., builders of this unit, chose Union Indicators for their supreme reliability, compact design, and for the other features below:

Two types of Data Display Indicators are made by Union Switch & Signal: Digital, displaying 10, 12, or 16 characters, and Alpha-Numerical, displaying up to 64.

Infinite Retentivity—Both indicators require power only during response time and retain data visually and electrically until a new code is transmitted.

Electrical and Visual Read-Out—Electrical read-out of data is provided in the same form as the input. Data can be read out on a continuous basis without erasing the stored information. Visibility of digital read-out is excellent, even when indicators are mounted in rows. Both indicators operate directly on binary codes on a null-seeking basis, eliminating need for external translation equipment.

Write today for complete information on indicators and other electronic equipment manufactured by Union Switch & Signal.

"Pioneers in Push-Button Science"



UNION SWITCH & SIGNAL

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Write in No. 201 on Reader Service Card at start of Product Review Section

• Readers who say the "inch" can be accurate as any other arbitrary standard should specify which inch they mean. Agreement among the inch-using nations to adopt new definitions for the yard and pound won't take effect until July 1, 1959. Till then, the inch isn't a uniquely defined unit of length.

This is where the metric system has the advantage: It is consistent. It is recognized universally. It is even the only legalized system in this country, although not in common use. The customary English system of weights and measures never has been formally legalized by Congress.

There are now at least two "inches" used in the USA, and three among the English-system nations. Then there are the nautical "mile", the geographic "mile", and the statute "mile", each different. Not only does the British yard differ from that of the U.S., it differs from the Canadian, which differs from the U.S. In Australia, the government standards commission never set a formal value for the yard or inch.

Even with a standard international "inch" effective next July, the engineer and scientist will face conversion problems. These in themselves are the source of errors. And, as pointed

out by one reader, some of these errors are never corrected.

Those opposed to the metric system seem to base their arguments on only one leg of the engineering profession. But isn't engineering a matter of communication, as well as of precisely measuring things? Surely, if it is better to have one standard within the U.S. for that purpose, a universal standard would offer even greater advantage. Space/aeronautics technologies will never be confined to one country or one group of countries. Important contributions are being made in both metric and non-metric countries. It is to the advantage of all to have a common standard of measurement.

In any case, the trend toward the metric is here. What is becoming universal in the lab eventually must come to the production line.—Ed.

Cut-Rate Canadair 540?

... Our sales department has brought it to our attention that it is swamped with telephone calls and letters from interested persons, who after reading the announcement on page 13 of the October [1958] issue of AVIATION AGE, would like to take advantage of

the cut-rate price of a Canadair 540, namely \$625,000. Others, who have already received a quotation for the airplane for the correct price of \$1,248,980, are breathing fire upon our heads—somehow they feel they are shortchanged.

We do not know where you get the figure of \$625,000. We have searched our documents, brochures, and letters pertaining to the aircraft to see if we are in error and can find nothing to support that figure. Nevertheless we feel we should let you know the following:

a) The cost of a Canadair 540, built in Canada, and including radio, is \$1,248,980 in U.S. funds.

b) The cost of converting a 340 or 440 to turboprop is \$466,485 in U.S. funds. . . .

If our sales "swamping" is as good as they say, it would indicate that AVIATION AGE enjoys an extremely wide readership. Congratulations! . . .

G. Haynes Davies
Public Information Manager
Canadair Ltd.
Montreal, Canada

• Our source for the wrong figure of \$625,000 was a top Convair official. (The 540 is a conversion of the Convair 330-440.)—Ed.

PYLE *star-line* CONNECTORS

Assure long-lasting protection of vital connections under a wide range of extreme environmental conditions

Currently establishing itself as a performance leader in the missile systems field, Pyle-Star-Line connectors offer engineers an entirely new line of electrical connectors for universal military and industrial use.

With characteristics of construction and performance never before combined in compact, rugged, lightweight standardized connectors, they exceed NEC requirements and classes A, B, C and E of military specifications MIL C-5015C.

FEATURES

Tough, lightweight shell: Strength comparable to mild steel, yet weighs only 1/3 as much.

Anodic coating: Gives shell toughness of case-hardened steel. Takes up to 1800 volts to penetrate coating.

"Sandwich" insulation: Silicone laminate floats between two rigid discs. Silicone disc absorbs shock, lets contacts align themselves freely; rigid discs impart just the right amount of restraint. Gives all advantages of both flexible and rigid mountings.

Chamber sealing: Silicone insulation disc positively and completely prevents water, gas, moisture or dust from passing into shell.

Wide range of pin and socket configurations: Configurations from 2 to 100 poles available. Within each form size all inserts are interchangeable and reversible.

Write today for complete specifications.

the PYLE-NATIONAL company

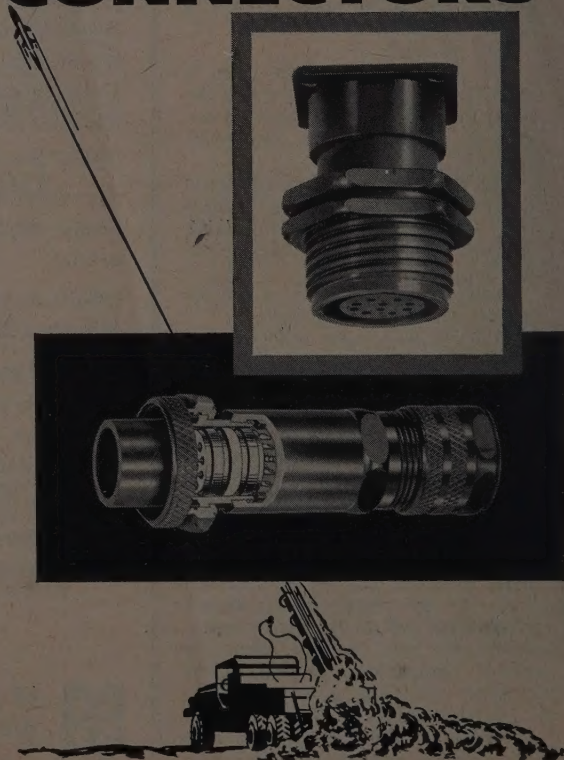
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CONDUIT FITTINGS • CIRCUIT CONTROLS • LIGHTING EQUIPMENT

Write in No. 202 on Reader Service Card at start of Product Review Section



New Center Has Unique Features

The Control Console in CECO's newest test facility incorporates latest state-of-the-art instrumentation and provides for push-button ease of operation. Any malfunction in any part of the system activates both audible and visual alarms. Electrical interlocks automatically shut down the system and indicate the specific area of malfunction.

If the operator does not or cannot take the necessary corrective steps within a predetermined amount of time, required corrections are made automatically and the test is resumed.

Engineered for Safety

While the Test Platform with its Ambient Chambers can easily be seen through a maximum safety window in the forward wall of the Control House, all tests are 100% remotely controlled. Operators set and control temperatures and pressures, and assemble all necessary data at the Control and Instrumentation Console.

The entire CECO Thermo-Research Center has been painstakingly engineered to provide optimum safety, both for operating personnel and for the valuable mechanisms being tested.

So thorough are the safety precautions that despite the hazards inherent in handling fuels at elevated temperature, lowest premium cost fire insurance premiums on this facility are in the category ("Sprinkler Rating").

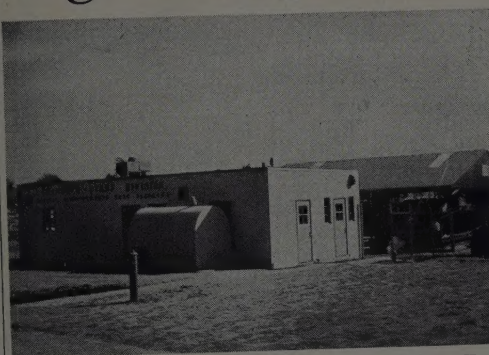
Described as "Operator-Proof"

A highly complex operator-overriding system, developed especially for this facility, assures proper operation at all times. Operator errors, if and when they occur, are corrected automatically.

Fuel Density Indicator

A meter in the Control House gives continuous indication of fuel density. It gets its signal from the intensity of radiation through a section of the fuel conduit. Isotope Cesium 137 is used in this radiation process.

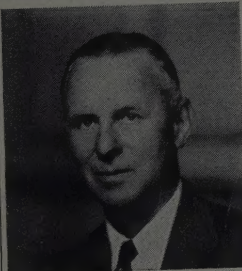
Chandler-Evans Announces New High-Temperature Test Center



LATEST CECO DEVELOPMENT TOOL: Two structures make up the Chandler-Evans Thermo-Research Center. One (shown above in foreground) is a concrete and steel, insulated and soundproofed Control House.

The second structure (background above) is an "open air" Test Platform, sheltered from the elements by a sheet metal roof containing plastic blow-out sections. Test Chambers and all associated equipment are installed on this platform.

S. A. Stewart Lauds CECO's New Test Lab



"This unique engineering tool will enable CECO to continue developing superior products empirically," said Sidney A. Stewart, General Manager of Chandler-Evans, when the company's new Thermo-Research Center was unveiled for the aircraft industry.

He went on to point out that high-temperature problems have become increasingly critical with advancing speeds of air and space vehicles. "We expect to find in this new laboratory definitive answers to a variety of questions relative to the precise metering of liquid fuels at high temperatures," he said.

Further underscoring the importance of temperature extremes in the modern aircraft and missile industry, Stewart mentioned concurrent ac-

tivities in the cryogenics field. He said CECO is designing and producing devices for use in liquid nitrogen systems, for example, where temperatures of -330°F . are encountered.

Part Numbering

To simplify troubleshooting and minimize time losses when repairs or replacements are required, each of the thousands of parts in the new test facility is numbered.

CECO Facility Tests Fuel Devices In Environments To 1000°F .

West Hartford, Conn. (CECO)—Completion of a new and vastly capable Thermo-Research Center has been announced by Sidney A. Stewart, General Manager of Chandler-Evans. The 100% company-owned facility is considered to be unique in the modern aircraft industry. It is designed to subject sensitive fuel mechanisms and other hydraulic devices to elevated temperatures similar to those developed in ultra high-speed flight.

As a development tool, the Center is expected to provide answers to many questions that have perplexed engineers since advanced air speeds first began to create critical high-temperature problems.

Chandler-Evans has been "hot-testing" aircraft engine accessory products for a number of years. Initially, relatively simple facilities were equal to the task. But, as aircraft and missile speeds advanced into Mach ranges, it became apparent that temperature problems would

(to accommodate 300-hour fuel system tests, for example) can be carried out twenty-four hours a day, seven days a week.

Others to Use Lab

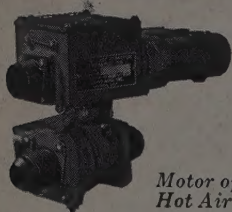
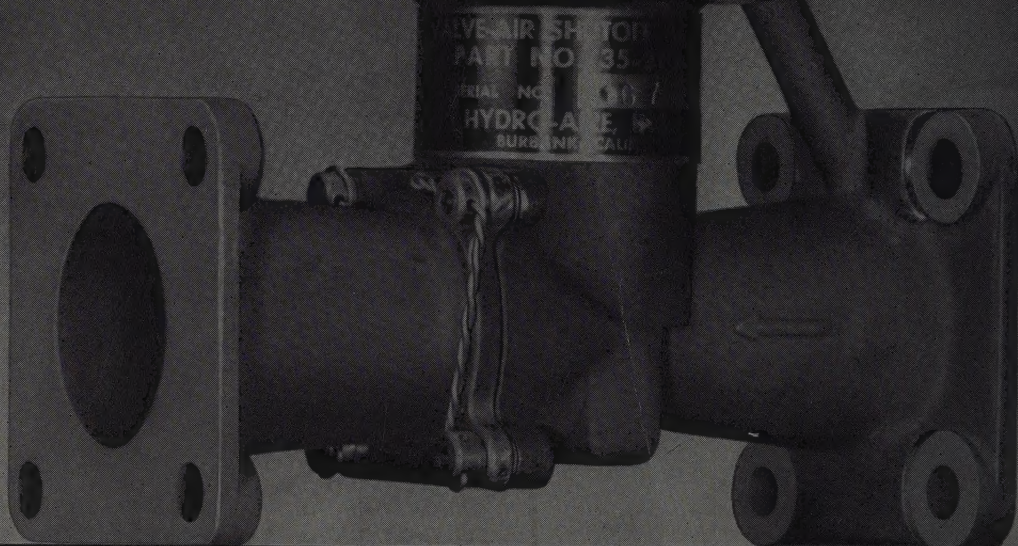
CECO's new Thermo-Research Center has been made available to others, according to Ercole J. Vitali, Manager of the Company's Engineering Test and Experimental Departments.

On a limited basis, the laboratory and its staff will be put at the disposal of manufacturers who are similarly concerned with the functional performance of liquid fuels, fuel system components, and other hydraulic equipment when subjected to the stresses of elevated temperature. Ambient and fuel temperature capabilities currently specified are 1000°F . and 500°F . respectively.

Vitali went on to say that subcontract customers can gain valuable time and save money as well by calling on CECO's engineering staff.

Chief Engineer for the well-known manufacturer of missile and aircraft fuel control systems and accessories, said the nation's newest jet-powered airplanes (Boeing 707s and Douglas DC-8s) are included among recent announcements for CECO production. In the missile field, Northrop's Shark, Raytheon's Sparrow III, and Chance Vought's Regulus II are airborne with products engineered and built by Chandler-Evans. The list of CECO-equipped military aircraft includes: KC-135 Stratoblasters, F-4 Phantom IIs, F-105 Super Sabres, F-106 Delta Dags, F-108 Super Hornets, F-111 Aardvarks, F-119 Stealth Fighters, F-120 Super Hornets, F-121 Super Hornets, F-122 Super Hornets, F-123 Super Hornets, F-124 Super Hornets, F-125 Super Hornets, F-126 Super Hornets, F-127 Super Hornets, F-128 Super Hornets, F-129 Super Hornets, F-130 Super Hornets, F-131 Super Hornets, F-132 Super Hornets, F-133 Super Hornets, F-134 Super Hornets, F-135 Super Hornets, F-136 Super Hornets, F-137 Super Hornets, F-138 Super Hornets, F-139 Super Hornets, F-140 Super Hornets, F-141 Super Hornets, F-142 Super Hornets, F-143 Super Hornets, F-144 Super Hornets, F-145 Super Hornets, F-146 Super Hornets, F-147 Super Hornets, F-148 Super Hornets, F-149 Super Hornets, F-150 Super Hornets, F-151 Super Hornets, F-152 Super Hornets, F-153 Super Hornets, F-154 Super Hornets, F-155 Super Hornets, F-156 Super Hornets, F-157 Super Hornets, F-158 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Hornets, F-776 Super Hornets, F-777 Super Hornets, F-778 Super Hornets, F-779 Super Hornets, F-780 Super Hornets, F-781 Super Hornets, F-782 Super Hornets, F-783 Super Hornets, F-784 Super Hornets, F-785 Super Hornets, F-786 Super Hornets, F-787 Super Hornets, F-788 Super Hornets, F-789 Super Hornets, F-790 Super Hornets, F-791 Super Hornets, F-792 Super Hornets, F-793 Super Hornets, F-794 Super Hornets, F-795 Super Hornets, F-796 Super Hornets, F-797 Super Hornets, F-798 Super Hornets, F-799 Super Hornets, F-800 Super Hornets, F-801 Super Hornets, F-802 Super Hornets, F-803 Super Hornets, F-804 Super Hornets, F-805 Super Hornets, F-806 Super Hornets, F-807 Super Hornets, F-808 Super Hornets, F-809 Super Hornets, F-810 Super Hornets, F-811 Super Hornets, F-812 Super Hornets, F-813 Super Hornets, F-814 Super Hornets, F-815 Super Hornets, F-816 Super Hornets, F-817 Super Hornets, F-818 Super Hornets, F-819 Super Hornets, F-820 Super Hornets, F-821 Super Hornets, F-822 Super Hornets, 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Hornets, F-871 Super Hornets, F-872 Super Hornets, F-873 Super Hornets, F-874 Super Hornets, F-875 Super Hornets, F-876 Super Hornets, F-877 Super Hornets, F-878 Super Hornets, F-879 Super Hornets, F-880 Super Hornets, F-881 Super Hornets, F-882 Super Hornets, F-883 Super Hornets, F-884 Super Hornets, F-885 Super Hornets, F-886 Super Hornets, F-887 Super Hornets, F-888 Super Hornets, F-889 Super Hornets, F-890 Super Hornets, F-891 Super Hornets, F-892 Super Hornets, F-893 Super Hornets, F-894 Super Hornets, F-895 Super Hornets, F-896 Super Hornets, F-897 Super Hornets, F-898 Super Hornets, F-899 Super Hornets, F-900 Super Hornets, F-901 Super Hornets, F-902 Super Hornets, F-903 Super Hornets, F-904 Super Hornets, F-905 Super Hornets, F-906 Super Hornets, F-907 Super Hornets, F-908 Super Hornets, F-909 Super Hornets, F-910 Super Hornets, F-911 Super Hornets, F-912 Super Hornets, F-913 Super Hornets, F-914 Super Hornets, F-915 Super Hornets, F-916 Super Hornets, F-917 Super Hornets, 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Hornets, F-966 Super Hornets, F-967 Super Hornets, F-968 Super Hornets, F-969 Super Hornets, F-970 Super Hornets, F-971 Super Hornets, F-972 Super Hornets, F-973 Super Hornets, F-974 Super Hornets, F-975 Super Hornets, F-976 Super Hornets, F-977 Super Hornets, F-978 Super Hornets, F-979 Super Hornets, F-980 Super Hornets, F-981 Super Hornets, F-982 Super Hornets, F-983 Super Hornets, F-984 Super Hornets, F-985 Super Hornets, F-986 Super Hornets, F-987 Super Hornets, F-988 Super Hornets, F-989 Super Hornets, F-990 Super Hornets, F-991 Super Hornets, F-992 Super Hornets, F-993 Super Hornets, F-994 Super Hornets, F-995 Super Hornets, F-996 Super Hornets, F-997 Super Hornets, F-998 Super Hornets, F-999 Super Hornets, F-1000 Super Hornets, F-1001 Super Hornets, F-1002 Super Hornets, F-1003 Super Hornets, F-1004 Super Hornets, F-1005 Super Hornets, F-1006 Super Hornets, F-1007 Super Hornets, F-1008 Super Hornets, F-1009 Super Hornets, F-1010 Super Hornets, F-1011 Super Hornets, F-1012 Super Hornets, F-1013 Super Hornets, F-1014 Super Hornets, F-1015 Super Hornets, F-1016 Super Hornets, F-1017 Super Hornets, F-1018 Super Hornets, F-1019 Super Hornets, F-1020 Super Hornets, F-1021 Super Hornets, F-1022 Super Hornets, F-1023 Super Hornets, F-1024 Super Hornets, F-1025 Super Hornets, F-1026 Super Hornets, F-1027 Super Hornets, F-1028 Super Hornets, F-1029 Super Hornets, F-1030 Super Hornets, F-1031 Super Hornets, F-1032 Super Hornets, F-1033 Super Hornets, F-1034 Super Hornets, F-1035 Super Hornets, F-1036 Super Hornets, F-1037 Super Hornets, F-1038 Super Hornets, F-1039 Super Hornets, F-1040 Super Hornets, F-1041 Super Hornets, F-1042 Super Hornets, F-1043 Super Hornets, F-1044 Super Hornets, F-1045 Super Hornets, F-1046 Super Hornets, F-1047 Super Hornets, F-1048 Super Hornets, F-1049 Super Hornets, F-1050 Super Hornets, F-1051 Super Hornets, F-1052 Super Hornets, F-1053 Super Hornets, F-1054 Super Hornets, F-1055 Super Hornets, F-1056 Super Hornets, F-1057 Super Hornets, 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Super Hornets, F-1104 Super Hornets, F-1105 Super Hornets, F-1106 Super Hornets, F-1107 Super Hornets, F-1108 Super Hornets, F-1109 Super Hornets, F-1110 Super Hornets, F-1111 Super Hornets, F-1112 Super Hornets, F-1113 Super Hornets, F-1114 Super Hornets, F-1115 Super Hornets, F-1116 Super Hornets, F-1117 Super Hornets, F-1118 Super Hornets, F-1119 Super Hornets, F-1120 Super Hornets, F-1121 Super Hornets, F-1122 Super Hornets, F-1123 Super Hornets, F-1124 Super Hornets, F-1125 Super Hornets, F-1126 Super Hornets, F-1127 Super Hornets, F-1128 Super Hornets, F-1129 Super Hornets, F-1130 Super Hornets, F-1131 Super Hornets, F-1132 Super Hornets, F-1133 Super Hornets, F-1134 Super Hornets, F-1135 Super Hornets, F-1136 Super Hornets, F-1137 Super Hornets, F-1138 Super Hornets, F-1139 Super Hornets, F-1140 Super Hornets, F-1141 Super Hornets, F-1142 Super Hornets, F-1143 Super Hornets, F-1144 Super Hornets, F-1145 Super Hornets, F-1146 Super Hornets, F-1147 Super Hornets, F-1148 Super 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Super Hornets, F-1240 Super Hornets, F-1241 Super Hornets, F-1242 Super Hornets, F-1243 Super Hornets, F-1244 Super Hornets, F-1245 Super Hornets, F-1246 Super Hornets, F-1247 Super Hornets, F-1248 Super Hornets, F-1249 Super Hornets, F-1250 Super Hornets, F-1251 Super Hornets, F-1252 Super Hornets, F-1253 Super Hornets, F-1254 Super Hornets, F-1255 Super Hornets, F-1256 Super Hornets, F-1257 Super Hornets, F-1258 Super Hornets, F-1259 Super Hornets, F-1260 Super Hornets, F-1261 Super Hornets, F-1262 Super Hornets, F-1263 Super Hornets, F-1264 Super Hornets, F-1265 Super Hornets, F-1266 Super Hornets, F-1267 Super Hornets, F-1268 Super Hornets, F-1269 Super Hornets, F-1270 Super Hornets, F-1271 Super Hornets, F-1272 Super Hornets, F-1273 Super Hornets, F-1274 Super Hornets, F-1275 Super Hornets, F-1276 Super Hornets, F-1277 Super Hornets, F-1278 Super Hornets, F-1279 Super Hornets, F-1280 Super Hornets, F-1281 Super Hornets, F-1282 Super Hornets, F-1283 Super Hornets, F-1284 Super 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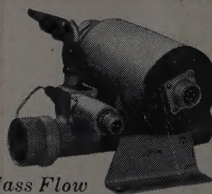
When pneumatic bleed
calls for control...



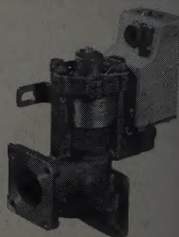
*Motor operated
Hot Air Butterfly Valves*



*Mass Flow
Control Valve*



*Pressure Regulator
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The featured player on this page is one of the latest additions to Hydro-Aire's family of pneumatic controls: a fast acting (less than a second) D.C. solenoid operated hot air shutoff valve. All dressed up in a precision casting (for low weight), it is ready to handle 250 psig at operating temperatures up to 900 degrees F. Because it is pilot operated, it's easy on current drain, and it can be supplied to fail safe open or closed. Below... some of its distinguished colleagues. If you don't see the one for your requirement, let us know. We're always happy to add to this family.

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